THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 55 — Thursday, October 8, 1936 — No. 1051

PUBLISHED WEEKLY

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

Institute of British Foundrymen

PRESIDENT: 1935-36

H. Winterton, "Moorlands," Milngavie, Dumbartonshire.

LIST OF SECRETARIES—

General Secretary: T. Makemson, Saint John Street Chambers, Deansgate, Manchester. London Office: 49, Wellington Street, London, W.C.2.

Birmingham, Coventry and West Midlands: A. A. Timmins, A.I.C., 21-23, St. Paul's Square, Birmingham.

East Midlands: B. Gale, "Parkdale," Boulton Lane, Alvaston, Derby.

Lancashire: J. E. Cooke, 1, Derbyshire Crescent, Stretford, Manchester.

London: H. W. Lockwood, Stewarts and Lloyds, Limited, Winchester House, Old Broad Street, London, E.C.2.

Middlesbrough: D. R. Kinnell, Chas. P. Kinnell & Company, Limited, Vulcan Ironworks, Thornaby-on-Tees.

Newcastle-upon-Tyne: W. Scott, Sir W. G. Armstrong, Whitworth & Company (Ironfounders), Limited, Close Works, Gateshead-on-Tyne.

Scottish: J. Bell, 60, St. Enoch Square, Glasgow.

Sheffield: T. R. Walker, B.A., "The Priory," Oughtibridge, near Sheffield.

Wales and Monmouth: J. J. McClelland, 12, Clifton Place, Newport, Mon.

West Riding of Yorkshire: S. W. Wise, 110, Pullan Avenue, Ecclesshill, Bradford.

Burnley: W. Haworth, 37, Westbourne Avenue, Burnley, Lancs.

East Anglian: J. L. Francis, 53, Cromer Road, Ipswich.

Falkirk: H. McNair, "Braewick," Larbert Road, Bonnybridge, Scotland.

Lincoln: E. R. Walter, M.Sc., The Technical College, Lincoln.

Preston: P. Leyland, 7, Ashley Terrace, Farington, Lancs.

The Institute of Vitreous Enamellers

President: Dr. J. W. Mellor, F.R.S., Sandon House, Regent Street, Stoke-on-Trent.

Chairman: W. H. Whittle, W. H. Whittle, Limited, Eccles, near Manchester.

Hon. Secretary: Miss E. Christine Elliot, 49, Wellington Street, Strand, London, W.C.2.

National Ironfounding Employers' Association

President: J. Smith, Smith & Company (South Shields), Limited, Nile Street, South Shields.

Secretary: Harold G. Judd, C.B.E., 8, Frederick's Place, London, E.C.2.

Foundry Trades' Equipment and Supplies Association

President: G. T. Lunt, "Briardene," Newbridge Avenue, Wolverhampton.

Secretary: K. W. Bridges, Grand Buildings, Trafalgar Square, London, W.C.2.

Welsh Engineers' and Founders' Association

President: W. E. Clement, Morfa Foundry, New Dock, Llanelly.

Secretary: J. D. D. Davis, 9, Royal Mesal Exchange, Swansea.

BRITISH CAST IRON RESEARCH ASSOCIATION

The Registered Office and Laboratories of the B.I.C.R.A. are:—
21-23, ST. PAUL'S SQUARE, BIRMINGHAM
Telephone: Central 1885. *Telegrams: CIRA*

The B.C.I.R.A. Scottish Laboratories are:—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone: 332

Contents

	PAGE
The Institute of Vitreous Enamellers	265
Sterlingarea	265
Paris Foundry High School	266
Correspondence	266
Institute of Metals	266
Notes from the Branches	266
Second Report of the Steel Castings Research Committee	267
Corby Works of Stewarts and Lloyds	270
Blast-Furnacemen's Working Hours	270
Book Review	270
Practical Importance of the Damping Capacity of Metals	270
Dutch State Steelworks	270
The International Foundry Exhibition at Düsseldorf: The Technical Section	271
The Effect of Non-Metallic Inclusions on the Graphite Size of Grey Cast Iron	272
Catalogues Received	274
High-Mn Steel from Low-Mn Ore	274
The Institute of Vitreous Enamellers—Third Annual Conference	275
Modern Tendencies in Vitreous Enamelling	279
The Week's News in Brief	284
Trade Talk	284
Forthcoming Events	284
Raw Material Markets	286

The Institute of Vitreous Enamellers

It seems appropriate at this juncture to review briefly the progress that has been achieved by The Institute of Vitreous Enamellers since its inception some three years ago. It was decided at the inception to make the Institute purely professional in its management and suppliers were specifically prohibited by the articles of association to share in its government. This rule has been strictly adhered to and the representatives of suppliers have in general appreciated their rôle as teachers, for in their hands lies a wealth of information which they are freely giving in the form of lectures and contributions to discussions. During the last three years a trade sign has been registered, which will signify that goods so marked are genuine vitreous-enamelled ware as distinct from synthetic substitutes. During the period of the Institute's existence some sixty Papers have been presented and some twenty works have been visited. Some of these, in Belgium and Germany, have been undertaken by the courtesy of the Institute of British Foundrymen, an organisation which the younger institute largely takes as its model. There has been a close association with the British Standards Institution in connection with matters germane to enamelling, and during the coming session, a number of foreign exchange Papers are to be presented.

The council has under consideration at the moment the creation of a research organisation for the industry, and at the President's suggestion, *pourparlers* have been opened with the British Cast Iron Research Association. There is obviously much to do, especially in the direction of finance, before a *modus operandi* can be established. Education, too, has been studied, but with the possible exception of Birmingham, the annual recruitment to the industry is insufficiently great to secure an adequate supply of students to make the establishment of classes worth while. A department of a modern university, which could draw upon the Dominions and foreign countries, might consider it worth while to attach a lecturer to some appropriate department where a general scientific course of study is in vogue, as there is apparently at the moment a dearth of suitably trained scientists.

We sincerely congratulate the new Institute on the progress it has made. Its officers realise that they have the task of changing a highly skilled craft into a definite science, and in full knowledge of this, the Institute will continue to prosper.

Sterlingarea

It is evident from the events of the past few weeks that France learned little from the experience of this country five years ago. At that time the press was full of warnings as to the dangers of going off the gold standard and of predictions of what would happen if we did. Immediately events forced us to go off (and we were pushed off), we were told that all sorts of advantages would follow, and indeed they have. Two things were necessary, public confidence in the country and a balanced budget. The former was shown by the extraordinary sight, to a foreigner, of people queueing up to sell gold at its enhanced price, and the latter followed. At the same time the existence of a group of gold countries and a group off the gold standard produced all sorts of trading difficulties. Scandinavia and the Empire countries followed this country's policy, and as a result a bloc tied to sterling rather than to gold was formed, and we said at the time not that we had left gold but that gold had left us. The suspension of the gold standard in U.S.A. also brought the pound and the dollar into some sort of relatively stable relationship. Everybody has known for five years past that devaluation was bound to come in France, yet the most determined efforts have been made to maintain it, and successive governments were pledged to defend the franc. The fear of a rise in internal prices and the objections of the fixed-income people were strong enough to keep the defence going. The result is that France has deprived herself of the profit on gold that has been leaving the country. The other result is an almost complete breakdown of the gold bloc, for Switzerland, Holland, Italy and other European nations have followed her example. The only country nominally on gold is Germany, an isolation which no doubt satisfies its economic nationalism, but at the same time, it is cynically said that the only country remaining on gold is that which has no gold at all. The change in France and elsewhere is all to the good; it will make for health and reality in economic operations and should aid in sweeping away restrictions on foreign trade. The French Government has now announced sweeping reductions in tariffs and quotas, to prevent rise in internal prices, and she hopes, perhaps naively, that other countries will follow this lead in tariff and quota demobilisation.

Paris Foundry High School

IMPORTANT CHANGES ENVISAGED

Striking changes are scheduled to take place at the end of the present school year in the conduct of the Ecole Superieur de Fonderie. Mr. E. Ronceray, the director of the school since its inception in 1924, is retiring, and is being succeeded by Mr. Albert Portevin, whilst Mr. R. Lemoine has been appointed assistant director. With the change, drastic alterations have been decided upon by the board of management on both recruitment and on the teaching undertaken at the school. For instance, degreed men will be admitted to the school without any entrance examination, as will non-diploma men who have practical foundry experience and who can prove themselves at an entrance examination to possess the general order of culture equal to that of an "ingenieur" (university graduate). In order to bring about the change-over from the old to the new *régime*, candidates of the second type will be re-examined for the forthcoming session in December, 1936, on the old syllabus for the entrance test, which will be applied much more strictly than previously. A new syllabus of a very much higher order will be established and put into operation in December, 1937.

Preliminary examinations in foundry practice are not compulsory for degreed men, but the taking of such is considered in the final placings of the students. Such an examination remains compulsory for non-degreed men. These ordinances, by giving a more homogeneous certification than previously, will allow of the stressing of the scientific instruction of the school, applying it equally to subjects that have reference to the manufacture of castings and to those which are more strictly metallurgical.

These two major subdivisions of the subjects covered will conserve the same relative importance previously established; that is to say, the equivalent number of lectures will still be the same. The total number of lectures, as such, will be drastically reduced, by cutting down those which are purely descriptive and of too simple a character. Practical and laboratory work will be correspondingly increased. Certain written work, such as the studies of moulding, will in a large measure be given under a simplified form by means of sketches and working instructions so as to reduce the actual work imposed upon the students and permit them to consider a larger number of examples during the course of a session.

All these modifications related to teaching will be so arranged as to take into account the previous practical foundry experience of the students, which is normally slight. The end sought is to raise their value as specialised executives, capable of rapidly adapting themselves to an industry of a very varied character and consequently able to play a proper part as leaders in this important branch of metallurgy.

Applications from degreed men for the session commencing December 3, 1936, will be received up to November 15, 1936, at the office of the Ecole Superieur de Fonderie, 151, Boulevard de l'Hôpital, Paris, 13. For non-degreed men the last day is November 8.

Carbonisation *v.* Nitriding

MR. C. T. EAKIN, writing on "Surface Hardening of Steel," in a recent issue of "The Iron Age," concludes that carburising steels cost less, machine more readily, are less liable to spall, and are more commercially available than nitriding steels. Carburised parts may be tempered to varying combinations of hardness and toughness, while this is not so practical with nitrided parts. The practical depth for a carburised case is $\frac{1}{8}$ in. or more, while nitriding is seldom carried beyond $\frac{1}{32}$ in. Nitriding produces a higher degree of hardness, results in much less distortion, and provides enormously higher corrosion and heat resistance than can be obtained by the carburising process.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

British Foundry School

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I trust that you will grant me the hospitality of your columns to advise all those in the founding industry—cast iron, steel and non-ferrous—that the British Foundry School has now opened for its second session. Entries for the session can be received until the end of the present month.

Employers desiring to nominate suitable men for the course can obtain forms of application from the Secretary, British Foundry School, c/o Central Technical College, Birmingham.

Applications can also be received from students desiring to take the course on their own responsibility and the Governors of the School have been assured by a number of education officers in various parts of the country that financial assistance can be provided for such men, where necessary. The initiative, however, must be taken by the student himself.—Yours, etc.,

R. G. HOSKING
(Chairman of the Governing Body, British Foundry School),
c/o Central Technical College,
Suffolk Street, Birmingham, 1.
October 5, 1936.

Foundry Developments in Germany

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—All those who saw the recent Foundry Exhibition at Düsseldorf will agree that scientific development in the German foundry industry is proceeding at a rapid rate, and the change compared with the 1929 Exhibition is marked. Those who saw German foundries will also agree that no time is lost in applying these developments in foundries through a highly trained personnel, and the Exhibition also indicated the variety of institutions available in Germany for providing metallurgical and foundry training from the lowest to the highest grade. It is important, therefore, that manufacturers in the industry should utilise to the full the resources available in this country if we are to keep pace with Continental developments.—Yours, etc.,

J. G. PEARCE
(Director, British Cast Iron Research Association),
21-23, St. Paul's Square,
Birmingham, 3.
October 5, 1936.

Institute of Metals

The Institute of Metals has just issued its programme of the meetings of the Institute and of its local sections for the session 1936-37. Four meetings of the parent body are planned. The first will be held in London on March 10 and 11, when the 29th annual general meeting will take place in the hall of the Institution of Mechanical Engineers. The annual dinner will be given at the Trocadero Restaurant between the two sessions of the annual general meeting. The annual May lecture—the 27th of the series—has been arranged to take place on Wednesday, May 5. This date has been chosen to meet the convenience of the overseas members who are expected to be in London at that time for the Coronation. In September, Sheffield will be the scene of the 29th annual autumn meeting of the Institute. Copies of the programme can be obtained on application to the secretary, Mr. G. Shaw Scott, M.Sc., 36, Victoria Street, Westminster, S.W.1.

SIR WILLIAM J. LARKE has accepted the invitation of the Council of the Junior Institution of Engineers to become President of the Institution in succession to Sir Frank E. Smith, F.R.S. Sir William, who is director of the British Iron and Steel Federation, will take office in December.

Notes from the Branches

East Anglian Section.—The East Anglian Section, which was formed early this year, held its first meeting on Thursday, October 1. The meeting had been preceded in the afternoon by a visit to the works of Lake & Elliot, Limited, of Braintree, by kind permission of Mr. W. B. Lake, J.P. The works proved to be of extraordinary interest and after a well-organised tour of the various departments the visitors were entertained to a most welcome tea.

In the evening, at the Central Library, Ipswich, MR. L. TIBBENHAM delivered the Chairman's address, which was followed by a film illustrating the oxy-acetylene welding of cast iron. The film had been loaned by the British Oxygen Company, Limited.

A vote of thanks to the Chairman was proposed by COL. C. PORTWAY and seconded by MR. H. H. SHEPHERD.

MR. C. H. KAIN then presented a *résumé* of the report submitted at the Annual Conference of the Institute in June, on "Dimensional Tolerances for Castings (with Particular Reference to Malleable Cast Iron)," by the Malleable Sub-Committee of the Technical Committee. The discussion which followed showed that the members present were fully appreciative of the work covered by the report and of the necessity of definite standardised tolerances for dimensions of castings. A vote of thanks to Mr. Kain was proposed by MR. H. H. SHEPHERD and seconded by MR. D. CARRICK.

MR. C. BOOTH, J.P., said a few words in appreciation of the efforts of the Chairman and Council in organising the meeting.

Falkirk Section.—A social evening, to open the coming session, will be held in the Argyll Restaurant, Princes Street, Falkirk, on Friday, October 16.

Scottish Branch.—The opening meeting of the 27th session will be held in the Royal Technical College, Glasgow, on October 10, when Mr. Frank Hudson will be installed as President and deliver the Presidential Address. Mr. Matthew Russell will read the Paper entitled "Fabrication *versus* Castings and the Possible Methods of Improving Foundry Technique to Meet the Competition," for which he was awarded the John Surtees Gold Medal.

At the conclusion of the meeting members and their ladies will attend a social function in the Ca'dora Restaurant.

Lancashire Branch.—Last Saturday, the members of the Lancashire Branch held a social evening at the Grand Hotel, and advantage was taken of the occasion to present to Mr. J. Hogg (President) and Mrs. Hogg a mahogany-cased grandmother clock to mark the completion of twenty-one years' continuous service in office with the Branch. The presentation was organised and made by Mr. R. A. Miles. Mr. H. Winterton (President of the Institute) and Mrs. Winterton were present to add their congratulations.

Wales, Monmouth and West of England Branch.—A meeting for all those interested in the foundry industry in the Bristol district is to be held at the Grand Hotel, Bristol, at 7.30 p.m. on Monday, October 12.

The President of the Institute, Mr. H. Winterton, and Mr. T. Makemson, the secretary, expect to be present and will address the meeting.

The Import Duties Advisory Committee give notice of an application for the addition to the Free List of ferro-silicon containing from 20 to 35 per cent. of silicon. Any representations which interested parties may desire to make in regard to the application should be addressed in writing to the Secretary, Import Duties Advisory Committee, Shell-Mex House, Strand, London, W.C.2, not later than October 22.

Second Report of the Steel Castings Research Committee

BY A JOINT COMMITTEE OF THE IRON AND STEEL INSTITUTE AND THE BRITISH IRON AND STEEL FEDERATION

SECTION I.—Introduction

Since the Committee presented its First Report, work has steadily continued, and a number of researches have been initiated, some of the results of which are included in the present Report.

Considerable changes have been made in the constitution of the Committee, which has been reorganised as a joint committee of the Iron and Steel Institute and the British Iron and Steel Federation, working under the Iron and Steel Industrial Research Council. In the course of reorganisation, every care has been taken to ensure that British foundry interests are suitably represented, and the Committee includes representatives nominated by the Institute of British Foundrymen, the British Cast Iron Research Association and the General Steel Castings Association. In addition, the Committee has appointed one of its members to represent them on the Steel Castings Sub-Committee of the Institute of British Foundrymen.

By these measures the Committee hope to avoid overlapping, whilst at the same time enlisting valuable help that can be contributed by these bodies.

The personnel of the Committee is as follows:

Mr. W. J. Dawson (chairman), Hadfields, Limited.

Prof. J. H. Andrew, the University of Sheffield.

Mr. H. H. Burton, the English Steel Corporation, Limited.

Mr. E. C. Evans, the British Iron and Steel Federation (representing the Iron and Steel Industrial Research Council).

Dr. R. H. Greaves, the Research Department, Woolwich.

Mr. D. W. Hammond, Wm. Jessop & Sons, Limited.

Dr. W. H. Hatfield, F.R.S., the Brown-Firth Research Laboratories.

Mr. F. J. Hemming, F. H. Lloyd & Company, Limited (representing the General Steel Castings Association).

Mr. F. N. Lloyd, F. H. Lloyd & Company, Limited.

Mr. J. E. Mercer, Head, Wrightson & Company, Limited (representing the General Steel Castings Association).

Dr. H. Moore, C.B.E., the British Non-Ferrous Metals Research Association.

Mr. W. J. Rees, M.Sc., the University of Sheffield (representing the British Cast Iron Research Association).

Mr. T. M. Service, Wm. Beardmore & Company, Limited.

Mr. T. R. Walker, B.A., the English Steel Corporation, Limited (representing the Institute of British Foundrymen).

Mr. K. Headlam-Morley (secretary), the Iron and Steel Institute.

In March, 1936, the Committee decided to set up a Sub-Committee to deal with all matters connected with moulding materials; as in the main Committee, due regard has been paid to co-ordination by the inclusion of representatives of other interested bodies.

The Sub-Committee is composed of the following:—

Mr. W. J. Rees, M.Sc. (chairman), the University of Sheffield (representing the British Cast Iron Research Association).

Mr. C. H. Kain, Lake & Elliot, Limited (representing the Institute of British Foundrymen Sand and Refractories Committee).

Mr. F. N. Lloyd, F. H. Lloyd & Company, Limited.

Mr. J. E. Mercer, Head, Wrightson & Company, Limited.

Dr. R. J. Sarjant, Hadfields, Limited.

Mr. J. J. Sheehan, the Austin Motor Company, Limited (representing the Institute of British Foundrymen Sand and Refractories Committee).

Mr. T. R. Walker, B.A. (secretary), the English Steel Corporation, Limited (representing the Institute of British Foundrymen Sand and Refractories Committee).

Many sections of this Report are to be discussed at a Joint Meeting of the Iron and Steel Institute and the Institute of British Foundrymen, to be held in the Lecture Theatre of the Institution of Civil Engineers, Great George Street, London, S.W.1, at 2.30 p.m. on Friday, October, 30.

The terms of reference of the Sub-Committee are as under:—

(1) To prepare a suitable bibliography on the subject of moulding materials.

(2) To consider and recommend such determinations of fundamental properties of refractory moulding materials as may be necessary for a proper consideration of the subject of moulding materials.

(3) To review the sources of British moulding materials and report on their suitability for steel-casting practice.

(4) To recommend and approve standard methods of testing foundry moulding and refractory materials of all kinds.

(5) When adequate experience has been gained to draw up tentative specifications under which such materials might be evaluated, with the ultimate object of purchasing under such specifications.

(6) To enunciate the desired specific properties of moulding-sand mixtures, such mixtures to be considered in relation to synthetic as well as to naturally-bonded sands.

(7) To lay down the precise method of preparation, degree of ramming, and the form of a standard mould for testing sand mixtures.

(8) To test the properties of sand mixtures under practical and comparative standard casting conditions.

(9) To investigate the application of new moulding materials.

The First Report of the Steel Castings Research Committee dealt principally with the examination of castings, many of them of intricate form, and produced in the course of ordinary manufacture. It was shown that there were considerable variations in practice in different foundries in the production of the same type of casting. The Report aroused considerable interest and was no doubt instrumental in further stimulating the tendency towards a scientific attitude in regard to foundry practice.

The present Committee, after careful deliberation, determined that their work could most usefully be pursued by individual and intensive study of the various basic factors which enter into the production of steel castings. The first results of these studies are presented in this Report.

Part I of Section II (prepared by Dr. R. H. Greaves) reviews existing information on dimensional changes, and on the strength and ductility of steel at high temperatures.

The Committee have given much thought to the complicated problem of the scientific determination of fluidity (sometimes referred to as "castability"), that is, the ability of the fluid metal completely to fill the mould. An examination of the Bibliography of the subject published in the present Report shows that much attention has been paid to the subject in the past; on the other hand, the investigations have been almost wholly concerned with cast iron and non-ferrous metals, very few accounts of experiments carried out on steel being available.

Part II of Section II by Dr. Greaves deals with this aspect of the work; it takes the form of a general theoretical study of the question, following which is an account of some experiments carried out by various members of the Committee.

Ultimately the Committee decided that the work was sufficiently important to justify the employment of a whole-time research worker in the applied science department of the University of Sheffield, under the direction of Professor J. H. Andrew. The experimental foundry in the metallurgical department is admirably fitted for such work, every facility being available for the manufacture of the necessary steel castings.

As will be seen in Section III of this Report, a standard method of testing the fluidity of steel has been worked out, which it is believed will render possible the determination of this property with sufficient accuracy to allow comparisons to be made in different foundries, and which will enable the Committee to test the influence of variations in properties of the different elements such as carbon, silicon, aluminium, chromium, phosphorus, and oxygen on the running powers of molten steel.

The Committee will specially welcome any constructive criticisms or suggestions that may help their further prosecution of this section of their work.

The Committee would direct special attention to the important research on the strength and ductility of steel whilst cooling down from the cast condition (Section IV); the work was carried out by Mr. H. F. Hall under the direction of Dr. Greaves. The results obtained by the very ingenious apparatus specially developed for this work are of considerable practical importance in relation to the manufacture of steel castings, particularly in regard to their bearing on the question of "pulls" or hot tears in castings whilst cooling down in the mould.

Moulding Materials Sub-Committee.—Section V of this Report relates to the work of the Moulding Materials Sub-Committee, and the actual results of their labours will be embodied in a future Report.

The present position of the radiological examination of steel castings is dealt with by Dr. V. E. Pullin in Section VI.

The Committee wish to take this opportunity to thank the Institute of British Foundrymen and the British Cast Iron Research Association for their willing co-operation with the Steel Castings Research Committee. It is hoped that in due course agreed methods of testing moulding materials will be formulated. Such agreement will render possible the preparation of suitable standard specifications to govern the purchase of certain classes of moulding materials.

The Committee cordially express their thanks to Col. W. MacC. Burden, C.B.E., M.I.Mech.E., Chief Superintendent of the Research Department, Woolwich, for the help that he has afforded in support of the Committee's investigations, and to Dr. Pullin for his contribution to the present Report.

Grateful acknowledgment is also made to the Department of Scientific and Industrial Research, the British Iron and Steel Federation and the Iron and Steel Institute, as well as to a number of individual manufacturers of steel castings, who by their help, financially and in other ways, have supported the work of the Committee.

Finally, they would pay a special tribute to the secretary, Mr. Headlam-Morley, and his staff for their valuable assistance, which included the preparation of the bibliography which forms part of the present Report.

SECTION II.—Properties of Steel which Affect the Quality of Steel Castings*

By R. H. Greaves, D.Sc. (Woolwich).

In order that the metal at all positions in a casting may show mechanical properties characteristic of its composition and heat-treatment, it is essential that soundness should be obtained throughout and that segregation should be reduced to a minimum, while such segregates as are necessarily formed are so disposed as to offer least interference with the mechanical properties.

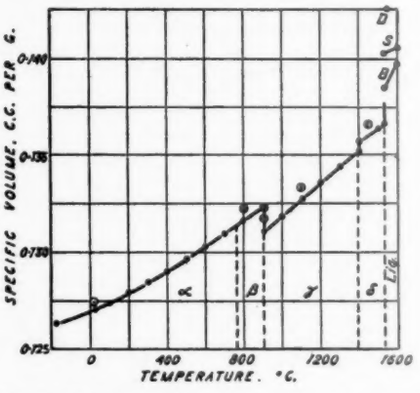


Fig. 1.—Effect of Temperature on the Specific Volume of Iron. (Desch and Smith[4]; Widawski and Sauerwald[3]; Benedicks, Ericsson and Ericson[2]; dotted circles, calculated from lattice parameter.)

The steel must possess sufficient fluidity to fill all parts of the mould, and the crystalline orientation, as revealed by the macrostructure, must be such as to confer the greatest possible strength on the casting as a whole.

Some of these features are far from being under control. Departure from the ideal conditions may arise as a result of the unalterable physical properties of the steel, and structural characteristics may be influenced by the design of the casting, even after all necessary precautions have been taken to ensure the highest possible standard in the product. A study of the effect of variations in the composition and other conditions on the factors involved may, however, help towards a more complete understanding of the behaviour of the metal in the mould and serve to direct attention to measures designed to mitigate the adverse effect of factors which cannot be completely controlled. Although this Paper contains a description of certain experiments bearing on the questions under discussion, it consists mainly of a summary of existing information relating to:—

(1) Some physical properties of liquid and solid steel which affect its behaviour in the mould; and

(2) the fluidity of steel in relation to the method of manufacture, composition and temperature of casting, with special reference to the practical application of the results of fluidity tests.

* Communication from the Research Department, Woolwich.

PART I.—Some Physical Properties of Liquid and Solid Steel which Affect its Behaviour in the Mould

The main difficulty experienced in obtaining soundness in steel castings arises from the behaviour of the steel in the mould during and after solidification. The formation of cavities and cracks is the result of a complicated series of changes to which a number of physical properties contribute. It should be the object of design, both of the form of the casting and of the method of moulding, running, and feeding, to minimise this composite effect; and when all that is possible has been done to reduce or release the stresses arising from contraction before they become dangerous, the advantage will still lie with the steel that possesses sufficient ductility in the hot condition to yield without cracking, under the stress imposed on it during cooling in the mould.

Thus, two outstanding classes of physical properties which govern the quality of steel castings are:—

(1) Volume changes which occur during the cooling of the liquid steel before and during solidification, and during the subsequent cooling of the solid steel; and

(2) the strength and ductility of the solid cast steel at temperatures from the freezing point downwards.

It is desirable in the first instance to summarise such information as is available on these two groups of physical properties of the liquid and solid steel, together with other properties which have a bearing on the temperature changes undergone by the metal in the mould.

Volume Changes from the Liquid State to Atmospheric Temperature

Laboratory Measurements. — The variation in specific volume of pure iron with temperature has been critically reviewed by Tammann,[1] and very little modification of his conclusions can be suggested. The most probable values for the density, specific volume and change in length of pure iron at temperatures from 20 deg. C. up to the melting point are given in Table I and

Table I.—*Linear Expansion, Specific Volume and Density of Pure Iron at Different Temperatures (Tammann and Bandel).*

Temperature. Deg. C.	Change in length. Per cent.	Specific volume. C.c. per g.	Density. G. per c.c.
20 ..	0.000	0.12699	7.875
100 ..	+ 0.097	0.12736	7.852
200 ..	+ 0.225	0.12785	7.822
300 ..	+ 0.375	0.12842	7.787
400 ..	+ 0.519	0.12898	7.754
500 ..	+ 0.682	0.12961	7.716
600 ..	+ 0.850	0.13026	7.678
700 ..	+ 1.015	0.13090	7.640
800 ..	+ 1.175	0.13152	7.622
906 ..	+ 1.335	0.13215	7.567
906 ..	+ 1.049	0.13103	7.632
1,000 ..	+ 1.250	0.13182	7.587
1,100 ..	+ 1.460	0.13263	7.540
1,200 ..	+ 1.675	0.13349	7.492
1,300 ..	+ 1.890	0.13433	7.446
1,400 ..	+ 2.100	0.13516	7.399
1,400 ..	+ 2.187	0.13551	7.383
1,500 ..	+ 2.380	0.13627	7.339
1,530 ..	+ 2.430	0.13648	7.327
1,530 ..	—	0.14034	7.126

Fig. 1. Measurements of lattice parameter give a slightly larger specific volume at all temperatures, *i.e.*, a similar solid contraction, but (when combined with the measured specific volume of the liquid) a lower freezing contraction.

Contraction in the Liquid State.—No satisfactory quantitative measurements have been made of the volume changes in liquid iron above the melting point. The rate of volume contraction of the liquid with falling temperature is not accurately known, but the following results, extrapolated from measurements on iron-carbon alloys, have been recorded:—

	Specific volume of liquid iron*—		Change per 100 deg.
	at melting point.	at 1,600 deg. C.	
	C.c. per g.	C.c. per g.	C.c. per g.
Benedicks, Ericsson, and Ericson[2] ..	0.1384	0.1397	0.0020
Widawski and Sauerwald[3] ..	0.1402	0.1405	0.0005

* Extrapolated.

The true value of the liquid contraction may lie between these figures. It is probably greater than the contraction per 100 deg. of the solid just below the freezing point (0.00076), but not so great as Benedicks' value. Both authorities agree that the effect of carbon is to increase the value of liquid contraction in the ratio 6:5 for 1 per cent. of carbon. It appears to be slightly increased by silicon, manganese, and phosphorus, and decreased by chromium and aluminium, but the observed effect of these elements is within the discrepancies between different results.

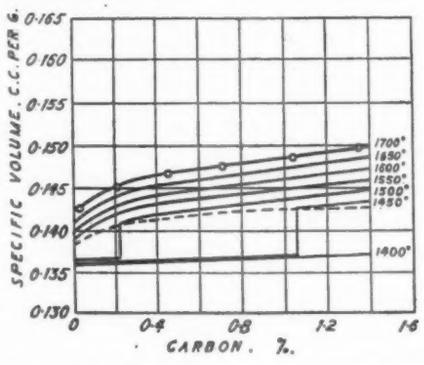


Fig. 2.—Specific Volume of Iron-Carbon Alloys at Temperatures near the Melting Point. (Benedicks, Ericsson and Ericson.[2])

Contraction on Solidification.—It is known that a considerable volume contraction occurs during the freezing of pure iron, but here again there are discrepancies[1] in the values, thus:—

	Change in specific volume on melting.
	C.c. per g.
Desch and Smith[4]	0.0061
Benedicks, Ericsson, and Ericson[2]	0.0019
Widawski and Sauerwald[3] ..	0.0037
Average	0.0039

which is 2.86 per cent. of the specific volume of the solid iron at the freezing point, or 3.07 per cent. of the specific volume at room temperature.

Ericson[2] has more recently made further determinations of the volume change on solidification by causing small spheres of iron to freeze and determining, by density measurements, the amount of cavity caused by contraction. His average results gave 2.4 ± 0.2 per cent. for the contraction due to solidification, expressed as a percentage of the volume of the solid iron at its freezing point. This value was corrected for visible surface depressions due to insufficient solidity of the outer crust, and hence leading to an inaccurate estimate of the volume of liquid metal, but it is possibly still low, since any symmetrical shrinkage of the outer crust would escape notice, and remain uncorrected for.

No accurate measurements are available of the effect on the freezing contraction of such differences in composition as are encountered in steels, but the results of the work of Benedicks, Ericsson, and Ericson[2] (see Fig. 2) suggest that

the volume change on solidification increases with the carbon content up to about 1 per cent. of carbon, and then diminishes again. The maximum change in specific volume at the melting point found by these observers was 0.005 for 1.04 per cent. carbon steel, *i.e.*, just under 4 per cent., as compared with their value of 1.5 per cent. for pure iron.

Contraction in the Solid State.—The effect of composition on the contraction of solid steel is dependent on the change in thermal expansion

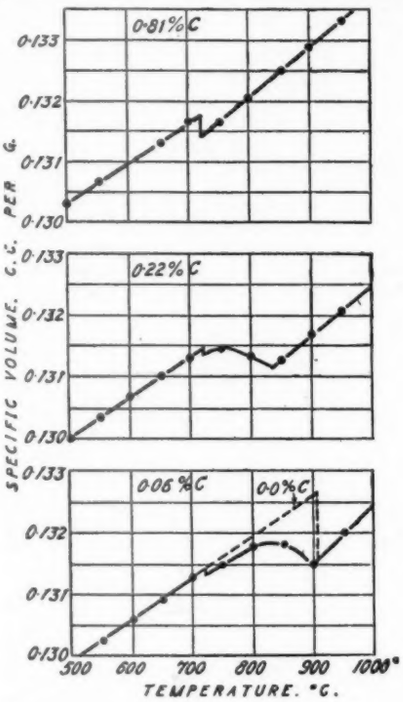


Fig. 3.—Effect of Temperature on the Specific Volume of Different Steels.

and the alteration in the volume change at the critical temperature brought about by the change in composition. The specific volumes of iron-carbon alloys containing 0.06, 0.22 and 0.81 per cent. of carbon for temperatures up to 1,000 deg. C. have been determined by Driesen[4] and are given in Table II. These values, which also indicate the character of the volume change

Table II.—*Specific Volume of Iron-Carbon Alloys at Different Temperatures (Driesen).*

Temperature. Deg. C.	Specific volume. C.c. per g.		
	0.06 per cent. C.	0.22 per cent. C.	0.81 per cent. C.
20	0.12731	0.12741	0.12776
100	0.12766	0.12777	0.12800
200	0.12816	0.12825	0.12855
300	0.12870	0.12878	0.12909
400	0.12930	0.12936	0.12969
500	0.12993	0.12999	0.13032
600	0.13058	0.13063	0.13097
700	0.13128	0.13130	0.13162
750	0.13149	0.13146	—
800	0.13173	0.13130	0.13205
850	0.13177	0.13124	—
900	0.13150	0.13165	0.13290
1,000	0.13237	0.13243	0.13375

on heating at the critical temperature, are shown in Fig. 3, and a similar change in the reverse direction (with the critical range at a slightly lower temperature) occurs on cooling. The thermal coefficients of expansion of steels of different compositions are fairly accurately known over a range of temperature up to about 700 deg. C., but information is lacking about the higher ranges of temperature.

Extrapolation up to the solidus temperatures of the steels suggests the following values for solid contraction from the solidus to atmospheric temperature:—

Carbon, per cent. ..	0.06	0.22	0.81
Temperature of complete solidification, deg. C...	1,500	1,482	1,335
Estimated specific volume at solidus temperature, c.c. per g.	0.13672	0.13625	0.13660
Solid contraction, percentage of length at 20 deg. C.	2.46	2.31	2.30
Solid contraction, percentage of length at solidus	2.29	2.16	2.15

There are no complete results over similar ranges of temperature for alloy steels, but the effect of alloy elements on the coefficient of expansion[1] gives some clue to the probable solid contraction. Thus, silicon and aluminium increase the coefficient of expansion of steel (Schulze). The effect of manganese in amounts up to 2 per cent. is slight (Matsushita), but over 2 per cent. it increases the coefficient of expansion, especially at temperatures over 500 deg. C. The effect of chromium (Stäblein), and tungsten (Honda and Matsushita) is to reduce the coefficient of expansion, but the effect is not large until a high percentage of the element is present. The effect of nickel in quantities up to 5 per cent. is to increase the coefficient of expansion slightly (Guillaume; Souder and Hidnert).

Total Contraction from 1,600 deg. C. to Atmospheric Temperature

The total contraction between 1,600 deg. C. and atmospheric temperature may be estimated from results obtained by Benedicks, Ericsson, and Ericson[2] on the liquid metal at 1,600 deg. and the known specific volumes of the corresponding materials at atmospheric temperature (Fig. 4). From these diagrams it is clear that all the elements shown, with the exception of carbon, affect the specific volume of the liquid at 1,600 deg. C. to about the same extent as they affect that of the solid at atmospheric temperature. The total volume contraction in low-carbon steel and in every carbon-free alloy (except aluminium) is between 10.0 and 10.5 per cent. Hence no marked change in the total contraction can be expected from the addition of alloy elements. The total contraction for 0.06 per cent. carbon steel is 10.5 per cent. A value of 2.45 per cent. for the linear contraction of

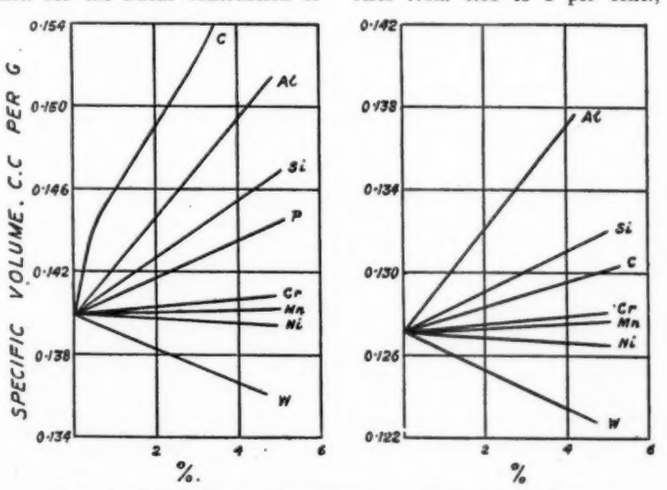


Fig. 4.—Influence of Composition on Specific Volume at 1,600 deg. C. and 20 deg. C.

the solidified metal corresponds to a volume contraction of 7.35 per cent., leaving 3.2 per cent. for the contraction of the liquid cooling from 1,600 deg. C. to complete solidification. The total contraction increases with the carbon content. With 1 per cent. of carbon the total volume contraction is 14.0 per cent., most of the increase probably being accounted for by a greater contraction on solidification. In the iron-aluminium alloy the total contraction is 9.2 per cent., and since the thermal contraction of the solid (judged by values of the coefficient of expansion between 20 deg. and 500 deg. C.) is increased, the indications are that aluminium reduces the contraction on solidification.

Conclusions

Laboratory measurements of the dimensional changes which occur in iron and steel as the metal cools from the liquid condition to atmospheric temperature thus lead to the following somewhat tentative conclusions:—

(1) Liquid contraction occurs in pure iron above its melting point to the extent of about 0.8 per cent. of its volume at atmospheric temperature per 100 deg. C. This value is slightly diminished by an increase of chromium and aluminium, and increased by carbon, silicon, manganese, and phosphorus.

(2) The contraction of pure iron in solidification is about 3 per cent. of its volume at atmospheric temperature. This is increased to a maximum of 4 or 5 per cent. with 1 per cent. of carbon, and then diminished again with a further increase in carbon.

(3) The linear solid contraction of pure iron from the freezing point downwards is 2.45 per cent of its length at atmospheric temperature. This is decreased slightly to about 2.3 per cent. with increase of carbon to 0.8 per cent.

(4) The equivalent values of the contraction of iron referred to the volume at atmospheric temperature and to the volume of solid at the melting point are:—

Percentage of volume of solid at	20 deg. C.	1,530 deg. C.
	Per cent.	Per cent.
Liquid contraction per 100 deg. C...	0.8	0.75
Freezing contraction	3.0	2.85
Solid contraction	$3 \times 2.45 = 7.35$	$3 \times 2.32 = 6.96$

(5) The indications are that the total volume contraction from 1,600 deg. to 20 deg. C. (expressed as a percentage of the volume at atmospheric temperature) is increased from 10.5 per cent. to 14.0 per cent. as the carbon rises from 0.06 to 1 per cent., but that it is unchanged as a result of the addition of small quantities of alloy elements, except aluminium by which the contraction on solidification is possibly reduced.

The summary of information given above is sufficient to indicate that the physical properties are not very accurately known over a wide range

(*Continued on page* 270.)

Corby Works of Stewarts and Lloyds

EXTENSION OF INGOT COMPANY

In connection with further developments at Corby Stewarts and Lloyds, Limited, are issuing to their shareholders the balance of the unissued capital, which will realise a sum of £1,355,000.

The company are offering to holders of deferred stock and liaison deferred shares the whole of the unissued deferred shares of £1 each. They total 1,042,910 and will be offered at 26s. in the proportion of one for every £5 of stock held, each liaison deferred share ranking as equal to £1,000 of deferred stock. The new shares will be converted into stock and will rank *pari passu* with the existing deferred stock as from January 1, 1937.

At the last annual general meeting, it is recalled in a circular issued by the directors of Stewarts and Lloyds, extensions then in progress at the Corby works were outlined. Since then the directors have decided to proceed with a further development on the Northamptonshire ore fields. This development, work on which is already in progress, is aimed at increasing the capacity of the Corby works by 150,000 tons per annum, bringing the total capacity up to about 600,000 tons per annum. It is believed that there will be no difficulty in disposing of the additional output. The demand from the tube works for Corby steel is increasing, and the shortage of basic-Bessemer billets for general purposes in replacement of Continental supplies falls also to be considered.

Agreement with Lanarkshire Corporation

The company, it is added, has entered into a conditional agreement with the Lancashire Steel Corporation, Limited, by which the latter will construct a new precision-type bar mill at Corby, and, for a long period, work up much of the output of Stewarts and Lloyds' mills in billets and slabs. Under these arrangements, the company will secure a guaranteed outlet for a large tonnage of semi-finished material, and added strength and security for the whole undertaking.

It is stated that profits for the first eight months of the year show an improvement on those for the corresponding period of last year and monthly profits are likely to show a further improvement during the last four months of the year.

Second Report of the Steel Castings Research Committee

(*Continued from page* 269.)

of composition, and that such knowledge as is available provides no grounds for supposing that any change in composition of the steel will have more than a slight effect on the magnitude of the physical constants involved. If it were necessary to rely on such measurements, information as to the effect of carbon and alloy elements on contraction in the mould would be scarce and its application to practice indirect. Much work has, however, been carried out on the practical determination of contraction, which, if of a lesser degree of accuracy, is more nearly related to the behaviour of cast steel in the mould.

(*To be continued.*)

REFERENCES.

1 G. Tammann and G. Bardel: "Heat Content and Specific Volume of Iron-Carbon Alloys," "Archiv für das Eisenhüttenwesen," 1933–34, vol. 7, p. 571.

2 C. Benedicks, N. Ericsson, and G. Ericson: "Determination of the Specific Volume of Iron, Nickel, and Iron Alloys in the Molten State," "Archiv für das Eisenhüttenwesen," 1929–30, vol. 3, p. 473.

3 E. Widawski and F. Sauerwald: "The Specific Volume of Liquid Iron," "Zeitschrift für anorganische Chemie," 1930, vol. 192, p. 145.

4 C. H. Desch and B. S. Smith: "Interim Report on the Density of Molten Steel, Third Report on the Heterogeneity of Steel Ingots," "Journal of the Iron and Steel Institute," 1929, No. I, p. 358.

5 G. Ericson: "Determination of the Change in Volume of Iron on Solidification," "Iron and Steel Institute, Carnegie Scholarship Memoirs," 1934, vol. 23, p. 13.

6 J. Driesen: "On the Rate of Expansion of Steels Containing Different Percentages of Carbon at Different Temperatures," "Ferrum," 1913–14, vol. 11, p. 129.

7 *See* J. W. Mellor: "Inorganic and Theoretical Chemistry," vol. 13. Iron, Part 2, pp. 555 (aluminium), 567 (silicon), 600 (chromium), 636 (tungsten), 659 (manganese); also "Bureau of Standards Circular No. 58" (nickel), "Scientific Paper No. 443" (chromium, nickel, and other steels); "Metals Hand Book," 1933, p. 406 (S.A.E. steels).

Blast-Furnacemen's Working Hours

REDUCTION TO FORTY-EIGHT A WEEK

As a result of conferences which have taken place in London during the past twelve months, between the National Council of Associated Ironmasters and the National Union of Blast-furnacemen, an agreement has been reached under which blast-furnacemen's working hours will in due course be reduced from 56 to 48 per week.

Main principles have been agreed, but there are still outstanding some details which require consideration and adjustment before the new scheme can be brought into operation. The manufacture of pig-iron being a continuous process, the operation will consist, as at present, of three shifts of eight hours each 24 hours, but under the new scheme the "long turn" on Sundays will be abolished, and each man will have one day off per week.

The increased cost occasioned by the agreement for a shorter working week is to be borne by both the men and the employers. Mr. T. McKenna, General Secretary of the National Union of Blast-furnacemen, stated on Monday that the total increase would amount to 16¾ per cent., and under the agreement the men would contribute 6 per cent. and the employers 10.66 per cent. It is expected that employment will be found for a considerable number of additional men. Mr. McKenna explained that the men would be graded up from lesser-paid and lesser-skilled jobs to the higher work. A slagger would be promoted to the position of keeper, a helper to that of slagger, a frontside labourer to a helper, and the additional men required would come in as labourers. The same process would operate on the filling side of the furnace and also in the machinery department.

The agreement covers the whole of the blast-furnacemen in England and Wales, with the exception of those employed at two plants, the owners of which are not affiliated to the National Council of Associated Ironmasters, with whom the agreement has been negotiated. Scotland is not included in the agreement, the men not being members of the union nor the employers members of the National Council of Ironmasters.

Book Review

The Mechanical Testing of Metals and Alloys. By P. Field Foster, M.Sc. Published by Sir Isaac Pitman & Sons, Limited, Pitman House, Parker Street, Kingsway, London, W.C.2. Price 15s. net.

It might be thought a difficult matter to write at this date a new text-book on the mechanical testing of metals and alloys, offering anything beyond what is already available, but the author of this work has most commendably succeeded. It is neither on the one hand another book on the theory of strength of materials, nor a catalogue of testing machines and methods, but occupies an intermediate position. Its up-to-date character is reflected in the section on testing equipment and also in such chapters as that on the structure of metals, in which an attempt is made to interpret structure, deformation and fracture in terms of the space lattice. Cast metals are given a share of attention. While no attempt is made to assess the results of research on fatigue and creep in relation to cast and wrought metals, it would be unfair to expect completely comprehensive treatment on this and other points in a work of this size. Details are given of B.S.I. Specification 321 for cast iron, now under revision. The usual method of calculating the breaking load on a standard transverse bar is given from that found on a non-standard bar. This transformation is purely mathematical and is erroneous if applied to other than small variations in size, since rupture stress varies so rapidly with section. It is stated that rough bars are stronger under transverse than planed bars, but it is now generally accepted that skin-machining gives a stronger bar.

The book is well printed and produced and well illustrated, although we are inclined to query the advisability of advertisements at the end of a book of this character. J. G. P.

Practical Importance of the Damping Capacity of Metals

At the Autumn Meeting of the Iron and Steel Institute, held in Düsseldorf recently, PROF. DR.-ING. O. FÖPPL read a Paper on "The Practical Importance of the Damping Capacity of Metals, especially Steels." We append the author's summary.

Under cyclic stresses well within the fatigue limits, many steels exhibit appreciable plastic strains. The "damping capacity" depends on the ratio of the plastic to the elastic strain, and is best defined by the non-dimensional ratio ψ obtained by dividing the area of the hysteresis loop by the strain energy stored in the extreme positions of the cycle.

Damping does not foretell impending fatigue failure, nor does it tend to disappear under prolonged cyclic stressing. On the contrary, it is capable of dissipating an unlimited amount of energy in heat without damage to the material. Ultimate damping, *i.e.*, the steady value attained after some millions of cycles, is often considerably greater than initial damping.

Unlike most other mechanical properties, the value of ψ is not affected by weak spots and is independent of the form of the specimen. The value of ψ is of great importance as a criterion of suitability, (1) because a high value of ψ confers notch-toughness in fatigue, and (2) because it controls the amplitude of undesired and often dangerous vibrations at critical speeds.

The Paper mentions five different methods of measuring ψ in use at the Wöhler Institute, and between which good agreement has been obtained. The method of free torsional vibrations receives preferential treatment, and the Föppl-Pertz apparatus is described in some detail. Damping curves are given for different materials, including a range of crankshaft steels. Damping in torsion is compared with damping in flexure. The limits within which damping is independent of frequency are also discussed.

The great and increasing importance of the damping capacity of materials in many different fields of engineering is illustrated by reference to aerial cables, aeroplane wings and propellers, crankshafts of internal-combustion engines, steam turbine blades, and welded *versus* riveted construction. Finally, attention is focussed on the need for finding a ductile steel which will give high damping at low stresses.

Dutch State Steelworks

The report of the Dutch State steelworks, Kon. Ned. Hoogovens en Staalfabriken, N.V., states that the new works for making sand-spun pipes will be started up before the end of the current year. Total pig-iron output of the concern in the financial year ended March 31 last was 256,411 metric tons, as against 261,531 tons in the previous year. Coke production was 268,165 tons, against 267,114 tons. Increased competition was experienced during the year, notably from Russia, and the gross turnover registered a slight decline. While world pig-iron output has advanced, consumption in Holland has fallen off from 43,466 tons to 40,253 tons. About 85 per cent. of the concern's production is exported, so that trade has been particularly susceptible to international restrictions. The net profit for the year was £12,400, against a loss of £10,700 in 1934-35; the accumulated deficit is now £570,000.

Welding Notations

The Institute of Welding has issued a "Draft Code of Symbols and Notation for Defining Standard Fillet and Butt Welds on Drawings." The Draft will be reviewed in the light of information received, and any comments and criticism should be forwarded to 7/8, Holborn Hall, Gray's Inn Road, London, not later than Monday, November 30, 1936.

The International Foundry Exhibition at Düsseldorf

THE TECHNICAL SECTIONS

The situation of the International Foundry Exhibition at Düsseldorf, amongst the gardens close to the banks of the Rhine, was particularly charming. It was divided into nine halls, having an area of over 150,000 sq. ft., of which 30,000 sq. ft. were devoted to purely technical exhibits. These exhibits were divided into thirty-two sections, each being organised by an eminent scientist.

The first section, by means of models and coloured tapes, depicted the blending of men, material and capital into a composite entity which goes to make up the modern works. It also covered the progress of work from the arrival of the raw materials to the despatch of the finished article. Quite a large amount of space was devoted to the organisation of labour, and many curves were displayed which dealt with various aspects of time-studies. A second section correlated, by means of diagrams, the cost of castings with the labour expended. A number of costing systems were also shown diagrammatically.

We received the impression that the section devoted to heating and ventilation was not quite so well arranged as might have been the case, and quite possibly more progress has been registered in this country than on the Continent.

Economic Utilisation of Energy

The section devoted to the economic utilisation of energy was well illustrated with charts, photographs and models. Diagrams of coal and its by-products and the gas grids of Germany, and models of gasholders and cylinders were typical of exhibits relating to gas production, whilst for electricity there were models, photographs and diagrams covering such activities as generation, distribution and application of electricity to domestic and industrial heating and lighting. Both high- and low-frequency melting furnaces were shown as models.

Mechanical Handling

The object of this exhibit was to show the various methods of handling material both on the ground level and at a height. The exhibits ranged from barrows to band conveyors, and lifts to magnets. Close by was a stand devoted to the planning and building of foundries, and to illustrate the development a series of photographs and pictures of foundries from the 14th century to recent times was included. An interesting exhibit at the side of this was formed with the object of displaying the German literature available to the foundry technician.

Welfare

The seventh section carried the title *Schönheit und Sichereit der Arbeit*, which, literally translated, means Beauty and Safety of Work; but we feel that the word "Welfare" adequately covers the ground. The usual safety-first measures were outlined, and a selection of posters exhibited. A certain amount of publicity was given to decent surroundings of working places.

For the overseas visitors, the exhibits (mainly comprising photographs and diagrams) outlining the educational system in Germany for the training of foundry apprentices and technicians were particularly impressive. The technical Institutes of Aachen and Clausthal were shown to be particularly well equipped, while the quality of the research done is universally acclaimed.

Raw Materials

This important exhibit was divided into seven sections, each one exhibiting not only typical castings but a mass of graphed data. The first section was that of non-ferrous metals, and was sub-divided into heavy and light alloys. Most of these exhibits were correlated with the appropriate DIN specifications (the German equivalent of the British Standard Specifications), and in the majority of cases also the chemical composition was given.

In the malleable cast iron section were illustrations and models of all the various types of furnaces available for melting the metal and for annealing. In addition there were lay-outs for malleable foundries and details included of the properties of the metal, ranging from straight tensile to welding tests. On this stand, too, there were many samples which showed the correct and incorrect methods of design, pattern-making and running. Many examples of typical castings and a statistical survey of the trade made this one of the best exhibits in the show.

Steel castings were not quite so fully dealt with, but the technique of pipe casting was splendidly displayed and covered both spun and pit-cast varieties.

The exhibit of ordinary grey-iron castings had been organised by Prof. Piwowarski, and as would be expected was of a high-grade metallurgical character. It showed very clearly the present position occupied by high-duty cast iron in the realms of heat, wear and acid resistance. The last two major exhibits embraced within the general section of raw materials were white iron and rolls, and die castings. Examples under the former heading were shown of material running to 90 and 100 Shore hardness.

Testing of Materials

This collective exhibit admitted of three main sub-divisions—mechanical testing, X-ray examination, and chemical and metallographic analysis. For mechanical testing about ten varieties of hardness testers were shown, together with a wide range of universal and impact testing machines. The X-ray exhibit was centrally situated and attracted a maximum of interest amongst the visitors. The chemical analysis and metallographic exhibit was as near complete as human endeavour could make it, bearing in mind its purely educational objective.

Foundry Practice

This section made a start with the pattern-shop; the exhibit reviewed the appropriate DIN specifications and explained why certain types of timber were to be preferred. The really practical side was exemplified by a number of finished patterns designed to demonstrate various technical points, including metal and master patterns. The actual construction of moulds surveyed very completely the field of running and risering, weighting of moulds, the techniques of venting and chilling, and the interrelationship of moulding with prior and post operations.

This exhibit was designed not only to show how various economies can be introduced into moulding practice, but also to interest the actual moulder in his work. The authorities who staged the exhibit ensured its appreciation by bringing on the Sunday of the duration of the Congress some 8,000 moulders. These moulders were marched round the exhibition and lectured to by experts during their progress. The mould and coremaking plant other than moulding machines was dealt with in a manner to trace the history and development of this type of equipment, and in no sense did it compete with the commercial exhibits housed in separate halls.

Mould materials were equally intelligently dealt with. The range of materials available was shown, and all the various methods of testing sands were clearly demonstrated. This section also included facings, and in this connection we have received the impression that Germany does not use foundry blackings to anything like the extent we do in this country. In general German graphite seems to be preferred.

Mould and Core Drying Stoves

In preparing a chronological invention or development chart of mould and core drying stoves the Germans have accomplished something which the British know little about. From this chart we learn that one of the principal inventors in Germany is the head of the firm of Mann, and whilst we were examining the doors of one of the models we had the privilege of being introduced to Mr. Mann by Mr. J. H. Cooper of Darlington, who tells us that he is probably undertaking the exploitation of this design of stove in Great Britain. This exhibit in general was particularly illuminating, for not only were there several models which one could almost take to pieces in order to examine the flue systems, but also there were a series of thermal efficiency diagrams and a wealth of technical data.

Foundry Machinery

Classed under this heading were moulding machines, sand preparing plant and fettling tools. Here, again, a chronological chart had been prepared of the major inventions in these three fields. Models only were shown of the various types of moulding machines, sand mills and sand-blast apparatus, so that there was no clashing with the commercial exhibits.

Pig-Iron and Scrap

Dr. Geilenkirchen was responsible for this section, which outlined the manufacture of pig-iron, and showed its structure, price movements, and such factors as the difference of sand- and chill-cast pig-iron. The Doctor was also responsible for a stand dealing with "other melting furnaces," covering air furnaces, Siemens and rotary furnaces, crucible, baby Bessemer and electric furnaces. Adjoining this was a stand devoted to melting practice for cast iron, which carried a large number of data sheets and efficiency graphs. The next important exhibit was that of the cupola, or rather shaft furnaces in general. The historical side was splendidly detailed, whilst the practical and theoretical aspects were fully demonstrated.

Dr. Pfannenschmidt had organised the exhibit dealing with the handling of liquid metal, which included such questions as shop control of composition and hardness and the additions of calcium silicide and alloys.

Surface Technology

A good deal of space was devoted to this important subject, which included sand-blasting, chemical treatments against rusting, metal spraying, Parkerising and Bonderising, galvanising, Sherardising and lacquering. Enamelling was separately considered, and here the historical side was dealt with, as well as the economic aspect. Examples were shown of majolica ware, acid-resisting material and sanitary ware, such as wash-basins and baths.

Welding

The last stand of all included a very comprehensive review of the science (or should it be art?) of welding. The classification used was rather interesting, as information was given under the following heads:—(1) Hot Welding: (*a*) electric, (*b*) gas. (2) Cold Welding: (*a*) electric, (*b*) gas. (3) Warm Welding: (*a*) electric, (*b*) gas. (4) Cast-Iron Hardening Processes. At the side of this exhibit was a collection of various welded castings made from iron, steel, non-ferrous and light alloys.

Conclusion

Will it ever be possible for any other country to stage such an extremely comprehensive technical exhibition? The reason why Germany can carry out such a large-scale enterprise is due to the excellence of the organisation of the employers' federation.

D

The Effect of Non-Metallic Inclusions on the Graphite Size of Grey Cast Iron*

By A. L. NORBURY, D.Sc., and E. MORGAN, M.Sc. (British Cast Iron Research Association, Birmingham)

Introduction

The present investigation deals with the problem of the graphite flakes in grey cast iron crystallising out in some cases in a very fine form and in other cases in a comparatively coarse form, for some cause not explained by chemical analysis or casting conditions. This phenomenon is apparently similar to that occurring in the case of the modified and unmodified aluminium-silicon alloys and certain other systems, and produces important alterations in the mechanical and other properties.

The results are reported in two parts, since different results were obtained on metal melted in small crucibles (Part I) from metal melted in the cupola (Part II), which presented new problems. In Appendix 1 are given some experiments on the effect of gases on cast iron, which were made during the investigation, and Appendix 2 deals with the freezing points of some iron-carbon-silicon eutectic alloys. The terms "fine" and "coarse" graphite are used throughout to indicate the supercooled and normal structures, and are only relative, since much coarser graphite than that shown in Figs. 1, 3, 5 and 7 is, of course, formed in large slowly-cooled sections of grey iron.

PART I.—SMALL CRUCIBLE MELTS

Graphite Nuclei Theory

When the investigation was commenced the current theory accounting for the above variations in graphite size was that they were due to the presence or absence in molten metal of undissolved graphite nuclei. Piwowarsky[1] and Hanemann[2] had found that superheating molten grey cast iron to about 1,500 deg. C. caused the fine graphite structure to form in the resulting castings, and suggested that superheating dissolved graphite particles which otherwise acted as nuclei and produced coarse graphite. It was, however, observed that the graphite nodules in blackheart malleable dissolved rapidly at temperatures as low as 900 deg. C., and this threw doubt on the above theory. In order to test it out further, melts were made, separately, first of a completely-white-iron thin section of a casting, and, secondly, of a coarse graphite grey-iron thick section of the same casting. No difference in the fracture of the resulting ingots could be detected, even on rapid melting at low temperatures, and this threw further doubt on the graphite nuclei theory. If the theory was incorrect, in so far as graphite size variations were not due to graphite nuclei, it seemed likely that these might be due to the presence of gases or non-metallic inclusions in the molten metal, and experiments were carried out to investigate this.

Method of Carrying Out Small Crucible Melts

In order to make a large number of melts rapidly, small ¼-lb. charges of cast iron were melted in fireclay crucibles in a Silit electric furnace, working at about 1,350 deg. C. Small ingots for the charges, instead of pieces of metal, were found to give a cleaner melt with less alteration in composition from oxidation. Melting took about twenty minutes. Slag was then removed and the melt treated, with the object, either of removing existing non-metallic inclusions from the melt, or of introducing new ones. The crucible was then removed from the furnace and cooled in air. The resulting ingots were slotted and fractured, the coarseness of the fracture was noted, and microscopic examination was made. The experiments carried out are recorded more or less in the sequence in which they were made, as are the resulting deductions, which were tested out by further melts. A 5 per cent. silicon, 1 per cent. manganese medium-total-carbon grey iron made from a synthetic crucible melt was used to begin with, chiefly with the idea of using a composition which would not so readily become mottled if silicon were lost by oxidation.

Treatment with Fluxes, Deoxidisers and Gases

The inclusions most likely to be present in the melt appeared to be silica and silicates (sulphur being below 0.03 per cent.) and the chief gases carbon monoxide and carbon dioxide. Consequently, in various melts, caustic soda and sodium carbonate were stirred in to try to remove the former, and deoxidisers such as sodium-lead, calcium-copper, magnesium, etc., to remove the latter. It was found that caustic soda additions coarsened the fracture somewhat, but no other special effect on the graphite size was obtained. This coarsening effect of caustic soda was subsequently found to be due to hydrogen, since bubbling hydrogen through the molten iron for about two minutes produced definite coarsening, while nitrogen produced definite refining. Nitrogen followed by hydrogen also produced coarsening, and *vice versa*. This result suggested that gases were the important factor, and a large number of experiments were carried out on their effects. These are reported in Appendix 1, since although it was found that hydrogen could make the solidified metal unsound and full of blowholes, little further information on the graphite size problem was obtained.

An iron of similar analysis, except that it contained only 0.03 per cent. of manganese instead of 1.0 per cent., was then made and experimented with to see if the manganese content affected the result. It was found, however, that the fracture of this iron was not affected by hydrogen or nitrogen, even when the manganese content was increased to 1 per cent. This iron appeared to give a stickier melt than the former, and attempts were made to flux out silica or silicates and then refine with nitrogen, but no refining could be obtained.

To see if phosphorus had an effect, 1.5 per cent. phosphorus irons were next tried, and it was found that some were refined by nitrogen but others were not. The fact that certain irons were refined by nitrogen, and others of the same composition were not, suggested that the refining action of nitrogen was due to the formation of a nitrogen compound, such as a nitride, and numerous experiments were carried out in which various elements were dissolved in the melt and nitrogen was then bubbled through. Various nitrides, nitrided steel, cyanides, etc., were also added. The most definite result obtained was that ferro-carbon-titanium additions appeared to clean melts of irons which were not refined by nitrogen, and if followed by nitrogen bubbling sometimes produced a certain amount of refining.

Effect of Ferro-Carbon-Titanium Additions

At this stage it was thought that ferro-carbon-titanium additions only had a cleansing action on the melt and that some other addition and treatment were required to produce the graphite refining. Titanium was also not thought to be responsible, since grey-iron test bars containing increasing amounts of titanium had previously been made without any special effect of titanium on their graphite size being observed.[3]

Experiments were consequently made in which the melt was cleaned by adding ferro-carbon-titanium and then given further treatment of various sorts, until a melt was made in which calcium carbonate was added after cleaning the melt with ferro-carbon-titanium. This was found to refine the graphite structure completely, and gave an ingot having a sooty black fracture, quite unlike anything previously obtained.

Ferro-carbon-titanium followed by carbon-dioxide bubbling gave the same result. Variations of the above treatment were tried, but it was found that 1 or 2 per cent. of ferro-carbon-titanium was sufficient and that it only produced the refining action when oxidised. Bubbling carbon dioxide for about two minutes also proved to be sufficient to produce the maximum graphite-refining effect. The above treatment was applied to a large number of hypoeutectic cast irons of the most varied compositions, and was found to refine them all; some were not quite so completely refined as others, and in hypereutectic irons the presence of kish graphite had a coarsening effect on the fracture and on the eutectic adjoining the kish graphite flakes.[4]

Bubbling hydrogen through melts treated with titanium and carbon dioxide was then found to produce coarse graphite structures. Additions of ferro-silicon and calcium silicide were not observed to coarsen such melts, whether added before or after the titanium plus carbon-dioxide treatment. Sufficient aluminium was found to prevent refining if added before, but not if added after, the titanium plus carbon-monoxide treatment.

Refining of Other Melts Connected with the Presence of Titanium in the Charge

The original 5 per cent. silicon, 1.0 per cent. manganese iron which was partly refined by nitrogen was then analysed for titanium and found to contain 0.15 per cent. It was found to be refined to a greater extent by carbon dioxide than by nitrogen, and completely by a ferro-carbon-titanium addition followed by carbon dioxide. The refining action of nitrogen was due to its indirect action of churning the metal and exposing it to surface oxidation, since refining did not occur in an atmosphere of nitrogen. The 5 per cent. silicon, 0.03 per cent. manganese iron, which was not refined by nitrogen, was then analysed and was found to contain only 0.05 per cent. of titanium. This iron was also refined when titanium was added and carbon dioxide bubbled through the melt. It was then discovered that the former iron had been made from a mixture of Swedish white iron, steel, and 30 per cent. ferro-silicon, and the latter from a mixture of Swedish white iron, steel and 40 per cent. ferro-silicon. Both ferro-silicons had been obtained from the same source, and it had been assumed that they had been made from the same materials, but on analysis the 30 per cent. alloy was found to contain 1.74 per cent. of titanium and the 40 per cent. alloy 0.08 per cent. of titanium. The 30 per cent. alloy turned out to be an odd lot from a Norwegian furnace. A subsequent supply of 30 per cent. alloy only contained 0.06 per cent. of titanium.

On finding that the titanium content was again connected with the fine graphite production, a number of other ferro-alloys and pig-irons were analysed for titanium. Swedish white iron was found to contain 0.04 per cent., hematite pig-irons about 0.07 per cent.; 1.5 per cent. phosphorus pig-irons, 0.15 to 0.30 per cent.; Burn (Indian) pig-irons, 0.25 to 0.30 per cent.; Norwegian pigs, such as Vantit and Norskalloy, up to 0.8 per cent., and 10 per cent. ferro-silicon 0.25

---

* A Paper presented to the Düsseldorf Meeting of the Iron and Steel Institute.

1 E. Piwowarsky, "Trans. of the American Foundrymen's Association," 1926, vol. 34, pp. 914–985.

2 H. Hanemann, "Stahl und Eisen," 1927, vol. 47, p. 693

3 A review of the literature on the effect of titanium on cast iron is given by E. Morgan in the "Bulletin of the British Cast Iron Research Association," January, 1935.

4 Excellent micrographs, showing fine graphite eutectic in hypereutectic melts, produced by melting in carbon crucibles and heating to 1,640 deg. C. in a vacuum, are given by H. Nipper, "Proceedings of the Institute of British Foundrymen," 1933–34 vol. 27, p. 127.

per cent. of titanium. It was found that these titanium contents broadly determined the fineness of the fractures obtained on remelting, when sufficient steel was added to produce a hypoeutectic melt.

For example, the hematites gave coarse fractures, the Norwegian pigs fine, and the addition of 10 to 20 per cent. of Norwegian pig to the hematite charge gave a fine fracture. The Swedish iron, which required the addition of silicon to make it grey, gave coarse fractures with 40 per cent. ferro-silicon (0.08 per cent. of titanium), but fine fractures with sufficient 30 per cent. ferro-silicon (1.74 per cent. of titanium), as stated above, and also gave fine fractures when sufficient 10 per cent. ferro-silicon (0.25 per cent. of titanium) was used. With upwards of about 50 per cent. of 10 per cent. ferro-silicon in the charge, completely fine fractures were obtained, and with less the fractures contained progressively less fine graphite. The finer graphite structures of test bars made as above from 10 per cent. ferro-silicon—finer than those made from 40 per cent. ferro-silicon—had previously been noted and reported,[5] but an incorrect explanation based on the graphite nuclei theory was put forward.

The fact that the differences between the titanium contents of the pig-irons and ferro-alloys almost completely accounted for the fineness of the graphite structures of the ingots produced from them, suggested that it was, in fact, the chief factor concerned.

Melting in Contact with Different Slags

Experiments were then made to see if the same refining result could be obtained by melting irons containing only traces of titanium in contact, for about twenty minutes, with a slag of suitable composition. Bearing on this, Diepschlag[6] has found that melting in contact with aluminous slags has a graphite-refining action on grey iron, and with siliceous slags a coarsening action. Similarly, Colbeck and Evans[7] have found that treating molten cast iron in the ladle with soda ash has a graphite-refining action and reduces the amount of sulphides and silicates in the metal. In these experiments gas was usually bubbled through the melt to give more intimate slag metal contact. A number of slags containing various mixtures of titanium oxide, ilmenite, ferrous silicate, aluminium oxide, silica, iron oxides, calcium oxide, calcium fluoride, sodium hydroxide, sodium silicate, manganese sulphide, manganese oxide, lead oxide, borax, cupola slags, etc., were tried, but no refining similar to that obtained with titanium and carbon dioxide could be produced. It was found that borax gave a white iron, due to absorption of boron, which has a powerful carbide-stabilising action, and additions of lead and lead compounds often produced a certain amount of refining. The effect of coating the interior surface of the fireclay crucible with various slags was also tried, without positive result. Similar tests were also made to see if an iron previously refined by titanium and carbon dioxide could be coarsened by stirring in or remelting with slags in the above manner, but again no positive result was obtained. It is important to note that these experiments were purposely carried out at comparatively low temperatures (1,300 to 1,350 deg. C.) in order to avoid superheating effects.

The general impression obtained was that non-metallic inclusions in molten cast iron were extremely difficult to introduce from outside, and that those present in the molten metal were probably almost entirely generated from chemical reactions with elements dissolved in the metal.

Melts Containing only Traces of Silicon

Experiments were next carried out with a view to obtaining further information on the nature of the inclusions which produced the fine graphite and of the others which produced the coarse graphite structure.

A melt completely free from inclusions was not obtained, but Swedish white iron (C.C 3.7 per cent., Si 0.2 per cent., Mn 0.03 per cent., S 0.03 per cent. and P 0.03 per cent.) to which 20 per cent. of pure nickel was added to ensure that it solidified grey, gave ingots having chiefly fine graphite in the microstructure. Such melts were apparently almost free from inclusions—with the exception of traces of silica and iron oxide—and were also free from silicon. Bubbling hydrogen through such a melt did not appreciably coarsen it. Treatment with titanium and carbon dioxide refined it completely. Bubbling hydrogen through a melt after treating it with titanium and carbon dioxide coarsened it completely. It had previously been found that stirring a fine graphite melt during solidification coarsened the graphite, and gas liberation probably has a similar tendency, but since the effect of hydrogen was so much greater on melts containing oxidised inclusions it appeared that its essential action was a reducing one, probably that of reducing FeO in the inclusions to iron.

Swedish white iron, without the addition of nickel, if melted without loss of carbon, gave an ingot which was just grey, and, like the above Swedish-nickel ingots, contained chiefly fine graphite. Additions of 40 per cent. ferro-silicon to this melt—steel being added if necessary to keep the iron hypoeutectic—gave coarse graphite structures, as stated above.

When small additions of 40 per cent. ferro-silicon were made, the coarsening was less in some melts than in others, apparently due to variations in the oxidation occurring since purposely oxidising the melt increased the coarsening.

Additions of calcium silicide to Swedish iron similarly gave coarse structures. The resulting ingots smelt strongly of acetylene, suggesting that calcium carbide had been formed. Experiments on the addition of sulphur and manganese to the Swedish iron before adding the calcium silicide suggested that calcium sulphide was formed instead of calcium carbide, if sulphur, not neutralised by manganese, was present in the melt. Bubbling carbon dioxide through melts treated with calcium silicide was found to remove the inoculating effect, which suggested that calcium oxide was not the inclusion formed. It had previously been found that ferro-silicon and calcium silicide additions had no appreciable coarsening action on grey iron melts that had previously been treated with titanium and carbon dioxide.

Additions of only 0.1 per cent. of aluminium to the Swedish white iron, which just went grey, coarsened it, but on allowing the melt to stew, or on bubbling carbon dioxide gas through it, a white coherent mass of aluminium oxide formed on the top surface of the melt, rather like a mushroom in coherence and appearance. If all the aluminium was oxidised out in this way, the resulting graphite structure was finer than that of the original Swedish iron, owing, presumably, to the removal by the aluminium oxide of some of the inclusions present in the original melt.

Refining Action of Copper in Excess of Liquid Solubility

It was also found that copper produced the fine graphite structure when it was dissolved in molten grey iron in excess of the quantity[8] which can be held in liquid solution at the temperature at which the graphite eutectic solidifies. The excess copper was precipitated in the melt during cooling down to the eutectic temperature in the form of liquid copper. Additions of copper in excess of the above liquid solubility limit did not have any appreciable graphite refining effect. That excess copper might have this refining action was deduced from, and investigated as a result of, the theoretical explanation given below.

Theoretical Explanation of Results

The production of fine graphite structures by the titanium plus carbon dioxide treatment, and of coarse graphite structures by the other treatments, appears in both cases to be due to the generation of inclusions in the melt. The different effects produced must consequently be assumed to be due to some difference in the nature of the inclusions generated. It is suggested that the different effects are due to differences in the freezing points of the inclusions, that when fine graphite structures are produced the inclusions are such that they are still liquid externally when the graphite eutectic solidifies, and that liquid inclusions do not inoculate it and it supercools. On the other hand, when coarse graphite structures are produced, the inclusions are solid and inoculate the graphite eutectic. The liquid inclusions probably contain eutectics, and are perhaps only liquid externally, having deposited solid internally. Inclusion-free melts are also assumed to supercool, and in this connection Hanson[9] found that iron-carbon-silicon alloys made from very pure materials and melted *in vacuo*, gave fine graphite structures, and that these were coarsened by remelting in air.

On the above theory, the inclusions produced by the titanium/carbon-dioxide treatment would be specially fusible ones. The freezing points of slags containing iron titanate are not known, but in the slag system diagrams compiled by Hall and Insley[10] manganese titanate and manganese silicate are shown to form a simple binary eutectic system, with the eutectic containing 22.3 molecular per cent. of $MnTiO_3$ and freezing at 1,120 deg. C., which is a lower freezing point than that of any of the iron-manganese-silicate slags mentioned in this review.

In order to test the theory, work is in progress on the separation and analysis of the inclusions in typical melts and the determination of their freezing points.

On the above theory, the coarsening action of hydrogen on a grey iron treated with titanium and carbon dioxide would be due to the reduction of ferrous oxide and the raising of the freezing point of the inclusions. The Swedish white iron melt made grey by nickel would be almost free from inclusions, as would be the Swedish iron melted by itself. Oxidised additions of silicon and aluminium and additions of calcium silicide would form silicate, aluminium oxide and calcium carbide particles of sufficiently high freezing points to produce coarse graphite. It is also suggested that the inoculating action of solid inclusions is local, and that when calcium silicide or ferro-silicon is added to molten cast iron a specially large number of inclusions is formed in the melt and produces a very uniform coarse graphite structure, which gives better mechanical properties in low-total-carbon grey irons than the less uniform graphite structure normally obtained. Copper in excess of the liquid solubility would precipitate liquid copper in the melt, which would coat existing solid inclusions with liquid and render them non-inoculating. Lead is also precipitated from liquid solution in a similar manner, and, as stated above, has some graphite-refining action, but it is not so effective as copper, possibly because it is only soluble to a very small extent, and also because it is heavy and sinks to the bottom of the melt. Other elements which are probably precipitated from liquid solution in iron are silver, bismuth, and thallium, but these have not been found to have any graphite-refining action, possibly on account of their solubilities being too low.

5 Norbury and Morgan, "Journal of the Iron and Steel Institute," 1930, No. I, p. 367.
6 E. Diepschlag, "Die Giesserei," 1929, vol. 16, p. 822; 1931, vol. 18, p. 705; 1934, vol. 24, p. 493.
7 E. W. Colbeck and N. L. Evans, FOUNDRY TRADE JOURNAL, 1931, vol. 44, p. 305; 1933, vol. 49, p. 191.
8 About 5 per cent. in ordinary grey iron. Silicon lowers this solubility figure.
9 D. Hanson, "Journal of the Iron and Steel Institute," 1927, No. II, p. 129.
10 F. P. Hall and H. Insley, "Journal of the Ceramic Society," 1933, vol. 16, p. 504.

The effect of superheating in producing fine graphite would be—as has been suggested by von Keil and his collaborators[11] since the above conclusions were arrived at—that of producing an inclusions-free melt, due to flotation, or reduction by carbon of the silicates present. Von Keil and Legat have suggested that the coarse graphite structures are due to submicroscopic silicate slime in the melt, but their only explanation of fine graphite structures is that they result from inclusion-free melts.

It is thought that the above theory also explains the modification of aluminium-silicon alloys by sodium and other elements which are thrown out of liquid solution and, it is suggested, coat existing solid inclusions with liquid and prevent them from inoculating the eutectic, which consequently supercools. Attention was previously drawn to the similarity between the normal and modified structures of aluminium-silicon alloys and those in grey cast irons, but the modification of the former was suggested to be due to the removal from the melt of solid particles such as oxides.[12]

PART II.—CUPOLA AND OTHER MELTS

Introduction

The experiments described in Part I suggested that the fine graphite structure could be produced in any grey cast iron by dissolving 1 or 2 per cent. of ferro-carbon-titanium in the melt and bubbling carbon dioxide through it. The fact that more successful results had not previously been obtained with titanium as a graphite-refining agent were assumed to be due to the omission of the oxidising treatment. This assumption proved, however, to be only partly correct, since attempts to apply the refining treatment to ladles of cupola metal under ordinary conditions met with little success, and further investigation was required, as described below.

Treatment of 50- and 200-lb Crucible Melts and Cupola Metal with Ferro-Carbon-Titanium and Carbon Dioxide

As soon as the refining action of a titanium addition followed by carbon-dioxide bubbling had been observed on the small ½-lb. crucible melts, attempts were made to duplicate the results on larger crucible melts and on cupola metal.

Charges of hematite pig plus 10 per cent. of steel were melted in 50-lb. and 200-lb. coke-fired crucible furnaces. 2 per cent. of ferro-carbon-titanium was then stirred in and carbon dioxide from a gas cylinder was bubbled through the melt for two minutes, through a stout ½-in. dia. steel tube, bent at right angles and protected by a plumbago sleeve over the arm dipping into the molten metal. In most cases a considerable amount of graphite refining, on 1.2-in. sand-cast bars, was obtained, but it was not complete and varied from one melt to another. Ferro-carbon-titanium was also stirred into ladles of cupola metal and carbon dioxide bubbled through, but the refining effect was considerably less than in the crucible melts, and hardly appreciable in most cases. Ferro-carbon-titanium additions to the cupola charge, with and without briquetting, gave similar results. It was observed that the ferro-carbon-titanium (melting point about 1,400 deg. C.) was difficult to dissolve and often became coated with slag, which prevented its solution in the melts.

Treatment of 50- and 200-lb. Crucible Melts and Cupola Metal with Ferro-Silicon-Titanium and Carbon Dioxide

Some ferro-silicon titanium (melting point about 1,200 deg. C.; Ti 20 per cent., Si 20 per cent., Al < 1.0 per cent., C < 1.0 per cent.) was then tried and gave much better results, and it was possible to obtain completely refined graphite structures throughout 3-in. dia. sand-cast bars, cast from crucible melts of hematite plus 10 per cent. of steel, treated by dissolving 1 or 2 per cent. of this alloy in the melt and bubbling carbon dioxide through it for about two minutes.[13] The untreated melt gave a very coarse graphite structure on a 3-in. bar. Complete refining, however, was not always obtained, and attempts to refine ladles of cupola metal with this alloy and carbon dioxide again usually proved almost completely unsuccessful, although in certain cases some refining was obtained. Moreover, little or no increase in the titanium content was found in the treated metal when refining was unsuccessful. It was thought that this was again due to difficulty in dissolving the titanium alloy and that one of still lower melting point would make it possible to refine ladles of cupola metal. Experiments were made and an alloy with a melting point of about 1,000 deg. C. was found, which was prepared by dissolving 35 per cent. of 80 per cent. ferro-manganese and 15 per cent. of 20 per cent. ferro-phosphorus in the ferro-silicon-titanium alloy. This alloy, however, did not give any better refining of ladles of cupola metal, and again only small amounts of titanium were found in the resulting casts.

Amount of Titanium Alloyed

Since it was assumed that the titanium alloy was still not dissolving, experiments were made on 2 per cent. additions at various temperatures and in the form of powder, lumps, etc. Titanium yields lower than the theoretical were, however, always obtained, in some cases even when single lumps of alloy were held below the surface of the metal until completely dissolved. This suggested that the low yields in the case of cupola metal were due not only to some of the alloy not dissolving, but also to titanium slag inclusion floating up out of the metal on account of its reaction with other slag inclusions in the melt. This also explained why, when added to certain melts, particularly ladles of cupola metal, the titanium alloy became rapidly coated with slag, which tended to prevent it from dissolving. It was found that the best and most consistent yield in a given melt was obtained by wrapping the titanium alloy in a thin sheet-steel packet and plunging it below the surface of the metal with a heated plumbago plunger. This made it possible to estimate the amount of titanium rejected by a given melt.

Additions of oxides, sulphides, slags, etc., were then made before dissolving 1 or 2 per cent. of the titanium alloy in the above manner, to see if they produced slag inclusions in the melt and reduced the titanium found in the resulting cast. Additions of deoxidisers and fluxes were also made to determine whether they increased the titanium yield. The results showed that oxidising additions reduced the titanium yield somewhat, but nothing like the reduction observed with cupola metal was ever obtained.

Ferro-Silicon-Titanium Additions to Crucible-Melted Pig-Irons

Two per cent. additions of ferro-silicon-titanium were then made to various pig-irons melted in the crucible, to see if some gave lower titanium yields than others on account of their containing more or different inclusions. Ten per cent. of steel was added to such charges to give a hypo-eutectic cast, and carbon dioxide was bubbled through the melt so that variations in the fineness of the fracture could be followed.

It was found that a higher titanium yield (*i.e.*, increased titanium content of the cast over the charge) was obtained on adding 2 per cent. of ferro-silicon-titanium (Ti 20 per cent.) to a pig of low titanium content (*e.g.*, 0.07 per cent. Ti) than one of higher titanium content (*e.g.*, 0.28 per cent.), since the titanium content of the cast was about 0.35 to 0.4 per cent. in each case. Similarly, on remelting such a cast and adding 2 per cent. of ferro-silicon-titanium and bubbling carbon dioxide through it, no increase in the titanium content was obtained. An addition of 4 per cent. of ferro-silicon-titanium to a 0.07 per cent. titanium melt gave, however, a titanium content of about 0.6 per cent. in the cast.

These results confirmed the view that titanium could dissolve and then float up out of the melt, but possibly only showed that the molten metal could not retain more than about 0.35 per cent. of titanium in the melt when it had been oxidised by carbon-dioxide bubbling. On the other hand, when the titanium was in the unoxidised form, in solution in the metal—such titanium probably forming titanium - carbide / graphite / austenite ternary eutectic[14] on solidification—greater amounts could be retained. When, however, cupola metal of a given titanium content was remelted in the crucible and titanium was dissolved as above, the titanium yield was lower than in the foregoing cases. This suggested that more inclusions, other than titanium ones, were present in cupola metal.

(To be concluded.)

11 O. von Keil and A. Legat, "Die Giesserei," 1933, vol. 20, pp. 214–217; O. von Keil, R. Mitsche, A. Legat, and H. Trenkler, "Archiv für das Eisenhüttenwesen," 1934, vol. 7, pp. 579–584; R. Mitsche, "Iron and Steel Institute, Carnegie Scholarship Memoirs," 1934, vol. 23, pp. 65–105.

12 A. L. Norbury, "Journal of the Iron and Steel Institute," 1929, No. I, p. 449.

13 A patent was applied for in 1933 and was granted in 1935 (No. 425,227). Certain foreign patents are pending.

14 Shimmer ("Transactions of the American Foundrymen's Association," 1886, vol. 15, p. 455) found the titanium (0.20 per cent.) in a Barrow No. 1 pig to be entirely in the form of titanium carbide (TiC).

Catalogues Received

Foundry Services, Limited, of 285, Long Acre, Nechells, Birmingham, 7, have used a new publication—a broadsheet which they have called Forseco News No. 1—to announce the development and marketing of several new products. Amongst these are a die dressing, especially for aluminium die castings; Recuperator C.7 for use in the recovery of metal from dross and skimmings; TR. 101, a new type of flux for tin and tin-base alloys; and a zinc indicator, a drop of which remaining on an ingot or piece of scrap indicates the percentage of zinc—if any. This publication will be sent to any of our readers on request.

Megger Insulation and Circuit Tester. Evershed & Vignoles, Limited, of Acton Lane Works, London, W.4, have used a three-page folder to illustrate and describe the "Good Companions" line of portable testing instruments, comprising both insulation and circuit apparatus. The dimensions of the case have been kept to a minimum and the weight is only 6½ lbs. It is the type of apparatus designed to obviate breakdowns, any one of which is likely to cost much more than the instrument.

Tool Steels. Two new catalogues, one dealing with carbon tool steel and the other with high-speed steels, have been recently issued by Edgar Allen & Company, Limited, of Imperial Steel Works, Sheffield, 9. In them details are given of the proper heat-treatment to be given to each variety of steel. The booklets contain a good deal of sound technical information and they are distinctly helpful in aiding one to choose the correct steel for any particular job.

High-Mn Steel from Low-Mn Ore

A successful process for making high-quality manganese steel when only low-manganese ore is available is claimed by a Swedish metallurgist, Helge Löfquist, at the Stockholm Metallographic Institute. A Swedish-American consortium has provided funds for the researches, which are of particular importance to the United States, which has hitherto been obliged to import high-manganese ores for its steel production. The processes evolved will, it is claimed, enable the extensive ore deposits of South Dakota to be utilised for high-quality steel in spite of their low-manganese content and high phosphorus. The Löfquist process will also be useful to Sweden by enabling low-manganese ores, hitherto considered of little value, to be utilised.

The Institute of Vitreous Enamellers

THIRD ANNUAL CONFERENCE

The third annual conference of The Institute of Vitreous Enamellers was commenced at the Midland Hotel, Manchester, last Friday, October 2, when a banquet and dance were held in the Alexandra Suite.

About one hundred and thirty members and guests were present, a figure only slightly lower than on previous occasions, which was due no doubt to the fact that the local enamelling industry is not so extensive as in the Midlands and London. Owing to illness, Mrs. Mellor was prevented from being present, and so was unable to join the President in receiving the guests.

Mr. W. H. Whittle (Chairman of The Institute of Vitreous Enamellers) presided, and he was supported by Mr. H. Winterton (President of the Institute of British Foundrymen), Mr. Barrington Hooper, C.B.E. (managing director, The Foundry Trade Journal), Dr. J. W. Mellor, F.R.S. (President of The Institute of Vitreous Enamellers), Mr. W. Todd, and Mr. D. Burton (managing director of the Pilkington Tile & Pottery Company, Limited).

The customary loyal toast was duly honoured.

The Vitreous Enamelling Industry

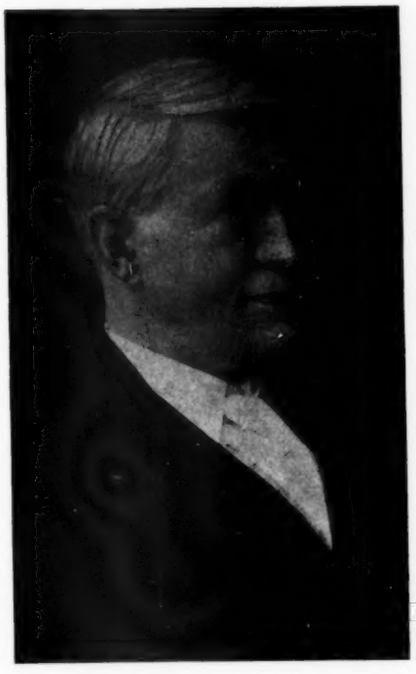
Mr. H. Winterton (President of the Institute of British Foundrymen), in proposing the toast of "The Vitreous Enamelling Industry," said that he was somewhat perturbed in his mind in connection with the toast which had been entrusted to him. One reason was that last year he understood that his immediate supporter on the right, Mr. Barrington Hooper, had the temerity to describe The Vitreous Enamellers in other terms. (Shame.) He was wondering whether any of those present would remember the terms which that gentleman had used. Personally, he did not agree with those terms; he would rather refer to them as the "virtuous" enamellers. (Laughter.) Unfortunately, their President had assured him that there were not any. (Renewed laughter.)

It gave him great pleasure to propose the toast of the vitreous enamelling industry and to couple with it the name of the Chairman, Mr. W. H. Whittle. If he might be permitted to say so, he (the speaker) had had some practical association with vitreous enamelling in connection with cast iron. Many years ago he remembered that a friend and himself had been experimenting, and he was quite certain that none of those present would have described them as "virtuous" enamellers, but rather more according to the phrase of his friend, Mr. Barrington Hooper, "vicious" enamellers. Sometimes they could not get the castings to take the enamel, and his friend blamed him, and he blamed his friend. The industry had progressed very much since those early days, largely owing to the efforts put forward by The Institute of Vitreous Enamellers. He felt, and in this he included also his wife, that they were the only people in the room who really bore evidence of the wonderful height to which The Institute of Vitreous Enamellers had brought their craft. He referred to the wonderful piece of enamelling which the Institute of British Foundrymen declared that their President and his lady should wear. However much progress might be made in the art of enamelling, he, personally, was convinced that it would not be possible to produce a more beautiful piece of work than that which they had the honour to wear.

He sincerely trusted that the Institute of British Foundrymen and The Institute of Vitreous Enamellers would progress hand in hand. They were, unquestionably, might he say, married to one another; at any rate, they were getting towards the end of a very long engagement.

New Plants and Inadequate Costs

Mr. W. H. Whittle (Chairman of The Institute of Vitreous Enamellers), in responding to the toast, said that Mr. Winterton was undoubtedly wearing a very fine specimen of the work which could be produced by the enamelling industry. Rapid strides had been made, but unfortunately, a number of firms had recently come into the industry mainly with the idea of putting down plant for the furtherance of their own work. Ultimately, they found they could hardly keep that plant going merely for the production of their own specialities, and then they were minded to go to the country for more work in order to keep their plants fully occupied. With new firms particularly, the tendency was to take work not knowing altogether what were the costs and so forth, to produce it, and sell at slightly less than other enamellers. This meant that instead of making up to a standard, such as the quality exhibited by Mr. Winterton's gold medal, they were compelled to make down to a price. The results were not in the best interests of the enamelling industry as a whole. The ultimate result of such a practice would be to drive the members of the industry closer together, apart altogether from the Institute, because intelligent co-operation was bound to be better than foolish competition. Most of them had to purchase the various materials they required, such as steel, fuel, etc., at definite standard prices, in regard to which there was no cutting of prices at all; and the high technical requirements of the industry demanded that there should be not merely a keeping up of quality, but also of price. The close contact between the two Institutes was one which was highly valued by all their members.



Dr. J. W. Mellor, F.R.S.
(President of The Institute of Vitreous Enamellers).

The Size of and Scope of the Industry

The toast of The Institute of Vitreous Enamellers was proposed by Mr. Barrington Hooper (managing director, The Foundry Trade Journal). He said he would like to congratulate all those present upon the efficiency of their Toast Master, who had come to him a little while ago, and remarked, "Will you make your speech now, or will you let them enjoy themselves a little longer." (Laughter.)

He regarded it as a very great compliment that during the three years the Institute had been in existence he had been invited to speak upon each occasion. Two encores, in three years, he presumed, must be regarded as a compliment. Nevertheless, an annual dinner was not an occasion to deal with the serious subjects and technical matters of vitreous enamelling, be it vitreous, or vicious, or virtuous. One's thoughts rather tended towards the consideration of the dancing which was to follow, and therefore his remarks would be brief. In the first place, worthy tribute must be paid to the toast he had to propose for the success of a young, though very virile, Institute, but he was constrained to refrain from making a lengthy speech about that organisation, bearing in mind the schoolboy's remark that "in America they put people to death by elocution." (Laughter.) It had been said that some speakers were welcome wherever they went, and some whenever they went. He would try to be among the former.

He had already declared that it was not his intention to speak seriously with regard to the business of vitreous enamelling, but he felt that he could not sit down without paying a worthy tribute to the work of The Institute of Vitreous Enamellers. He understood from Mr. Faulkner that the consumption of vitreous enamel was now in the neighbourhood of 18,000 tons a year, and that this quantity was sufficient to make an enamel sign a yard deep reaching from London to Singapore. He was not going to contest that statement, but he gave it to them for what it was worth. The vitreous enamellers had made an excellent start. At the end of three years they had considered something like 60 technical Papers, and they had established contact with various other associations. They were linked up with the Institute of British Foundrymen. It had been said that evil communications corrupt good manners. (Laughter.) Personally, he was a member of both; and he could assure them all that the proverb did not apply in his case. Contact had also been established with other coun-

tries in conjunction with the Institute of British Foundrymen, and also on their own account. Such contact with American, German, and other foreign societies was to be commended.

Association, friendship, and collaboration were all to the good. We could not, in this world of ours, live out a lonely existence. He had been told that the time had arrived when the trade sign of The Institute of Vitreous Enamellers would have passed through the various stages of red-tape officialism, and they would see it blazoning forth as a token of the world's best vitreous enamelling. This was a point which appealed to him, because it was a phase of advertising, and those who had tried it knew that advertising paid.

He hoped the Institute would go from strength to strength, for co-operation was the essence of good trade. One could not succeed alone. There was nothing more disastrous than trying to plough a solitary furrow.

Proposed Research Activities

Dr. J. W. Mellor, F.R.S. (President of The Institute of Vitreous Enamellers), in responding to the toast, expressed a feeling of envy for the after-dinner eloquence of the proposer of the toast. He was very grateful to him for his good wishes and good advice. As Mr. Barrington Hooper had said, the Institute was a very virile society. This was most certainly true as far as the Council was concerned, which was that part of the organisation with which he, the speaker, had had most experience. During the past year they had discussed an extraordinary number of suggestions for extending the work of the Institute and developing the technical side of the industry.

A suggestion to start a research association by the Institute was so vigorously supported by himself, the speaker, that he began to wonder if somebody might suspect that he had an axe to grind. He could assure everybody that he had no such idea in his mind. The Institute had, in every respect, earned his admiration for the wonderful commonsense way in which they had treated every problem which had arisen. Other industries had research associations which had been inaugurated mainly because they could not make much progress in obtaining import duties until they had demonstrated that they were doing their utmost to develop and improve their respective industries. The subject was perhaps outside the range of what ought to be touched upon on such an occasion, but there was no doubt whatever the more quickly such a research association was established, the better it would be for everyone concerned. Furthermore they would run no risks of getting a serious rebuff from the Board of Trade if ever they applied for import duties.

The Guests

Mr. W. Todd (Deputy Chairman of The Institute of Vitreous Enamellers), in proposing the toast of "The Guests," said that in the first place they had to appreciate the contact and co-operation which the members of The Institute of Vitreous Enamellers had always received from the corresponding body who safeguarded the interests of the foundrymen. The state of warfare alluded to by Mr. Winterton still more or less existed, even in their own establishments. The foundryman always expressed in picturesque language what he thought about the highly coloured stuff that was, sometimes, grey enamel, while the enameller always alleged that the trouble was due to inclusions, blow-holes, and other extraneous matters in the iron.

Nevertheless, the Institute did owe a very great deal of gratitude for the assistance of the Institute of British Foundrymen. Mr. Winterton had followed his predecessors by giving them his very loyal and cordial support, while another gentleman to whom they owed a great debt of gratitude was Mr. Barrington Hooper. He had been of immense value to the Institute in the early days, when the going was extremely hard, and had given them the benefit of his long years of experience in leading them on the right path.

Another gentleman whom he desired to mention was Mr. David Burton, managing director of the Pilkington Tile & Pottery Company, Limited, and he would like to couple with his name that of his co-directors, for their great kindness in permitting the members and their friends to visit their works. He had been asked also to express, on behalf of the Institute, sincere appreciation of the action of the directors of Tootal, Broadhurst, Lee & Company, Limited, for their kind invitation to the ladies to visit their Sunnyside Mills at Bolton. He hoped the gentleman members would not regret it, even though they might find orders had been placed for certain fabrics, and that all they had to do was "to grin and foot the bill." It was all more or less part and parcel in the game of life.

He did not think they would like to conclude the evening's proceedings without expressing their very deep sense of gratitude to Mr. H. Bradley, in particular. Mr. Bradley, like all conveners and secretaries generally, had, or hoped to have, the support of an enthusiastic and energetic committee, but, in fact, like all conveners and secretaries he found he had to do the bulk of the work. He did not think he would be betraying any confidence when he stated that Mr. Bradley had done excellent spade work, which should be fully valued and duly honoured.

Mr. D. Burton (managing director of the Pilkington Tile & Pottery Company, Limited) responded to the toast, stating that he represented an industry which was closely allied to that of vitreous enamelling, and which was confronted with very similar troubles which they endeavoured to surmount in their own particular way. In his own department of industry they had been enormously helped and encouraged by the work and activity of Dr. Mellor. Perhaps the society which most closely resembled The Institute of Vitreous Enamellers was the Ceramic Society. Well, Dr. Mellor *was* the Ceramic Society; and he, the speaker, invited the Institute to make the fullest use of Dr. Mellor's abilities. His mind went back to the number of times, in his own works, when problems had been tackled for periods perhaps extending over months. More or less satisfactory conclusions had been reached, and then, somewhat to their consternation, after thinking what extraordinarily clever fellows they were, they found that some manufacturer in Staffordshire had done similar work years ago. They were all, more or less, disposed to work in their own separate corners. If they could only get together, under the guidance of a man like Dr. Mellor, he felt that there was a great future in store for them all.

As the last speaker of the evening, he would like to tell them a story he heard the other night, hoping that they would apply its point to his response to the toast. It was a story of a couple who had been courting, or, as it was said in Lancashire, "walking out," for many years. One evening they found themselves in a park. After hours of silence, the girl said to the man, "Harry, say summ'at." He thought for a moment, and then he said, "Will'ta marry me, lass?" "Aye," she said, "I will." Dead silence again for about an hour. The girl again said, "Do say summ'at more, Harry." "Nay, lass; thur's bin 'nuff talk t'night."

Subsequently there was dancing in the Alexandra Room to the music of Orlando and his orchestra, while other entertainment was supplied by Mr. Ben Mayoh, "And, of course, a piano," and by Mr. Tom H. Jackson, "the Man with the Cards."

On the following morning, Saturday, October 3, members and friends were conveyed by coaches to the Pilkington Tile & Pottery Company, Limited, Clifton Junction, where they inspected the various processes of pottery production. A further party of ladies visited the Sunnyside Mills of Tootal, Broadhurst, Lee & Company, Limited, at Bolton, where numerous high-class textile fabrics, both in the processing and finished stages, were inspected.

The Technical Session

During the afternoon of last Saturday a technical meeting of the Institute was held, followed by an extraordinary meeting in connection with the revision of the articles of association. Dr. J. W. Mellor presided.

Mr. H. Bradley, Conference Secretary, read the minutes of the previous annual conference held in London, on September 28, 1935, which, being approved as a correct record, were signed by the President.

PRESIDENTIAL ADDRESS

Dr. J. W. Mellor, in delivering his presidential address, said:—I found out last Thursday afternoon that I had to give a presidential address, so I thought the most useful thing I could do, so far as the general features connected with our Institute are concerned, would be to give you a report of the proceedings that have been taken up to date in connection with the formation of a research association fathered by the Institute. There has been nothing done definitely yet. There are many side issues that have to be discussed, and which will be discussed in an open meeting, and which will be ventilated to the fullest extent, in order that the Institute may eventually adopt what they consider to be the wisest course to pursue. I have made some notes on the subject which I thought it would be handy for you to have for future reference, in order that you might know exactly how the matter originated and what has been the progress made.

So far as I can gather from conversations with various members of the Institute, demonstration of the need of a research association is unnecessary. Everybody seems to agree that the industry will greatly benefit by research work being undertaken.

A very important point in connection with such a research association as is contemplated by your Council is that it opens up the possibility of obtaining a fairly substantial Government grant if certain conditions are fulfilled.

B.C.I.R.A. Suggested

When the subject was first broached, I went to the Department of Scientific and Industrial Research and explained that this industry is comparatively small, that I did not see much prospect of passing the minimum amount required before earning grants from the Department, and that, in spite of the text: "Whosoever hath, to him shall be given," it did not seem fair for an industry to receive no support because it was only a small one. I was told that the difficulty could be overcome by joining up with the Cast Iron Research Association. After interviewing the director, I was delighted to find that it is possible to meet our conditions, and to found a suitable research association by linking up with the Cast Iron Research Association.

So far as I can see, the work of our research association would then proceed very much as it would if it were an independent body, and it would be able to earn a Government grant based on the magnitude of its subscription. The Cast Iron Research Association is willing to take us on, and it is up to us to make the next move. The work done by our research staff would be wholly under the control of our own managing committee, and I do not see what more could be desired.

Supposing £3,000 were raised, that would provide for three senior men with a junior apiece. One of these men could develop methods of testing materials and products, and do tests for the trade at a suitable charge—say 25 per cent. more for non-members than for members. The other two men could devote themselves to the particular branches of research selected by the

managing committee. At first, the staff would not be much use, but as soon as the men had acquired experience, the Association would be a great help to the industry, in dealing with technical difficulties, the improvement of old processes, and the development of new processes.

It is a mistake to suppose that if a factory has its own research department, it has no need for a research association. I have been rather impressed by the fact that in another research association with which I am connected, our strongest supporters are those manufacturers who have research laboratories on their own works. At first sight I should not have anticipated this, but, on second thoughts, I suppose that a research staff in a works can understand the work of the research association, and utilise it to the best advantage.

It seems very fitting that The Institute of Vitreous Enamellers should be prime-movers in inaugurating this research association. In an institute of this character, there will soon come a time when the original contributions are approaching exhaustion, and our Papers will tell and re-tell the same old old story. Without the stimulus of research, we shall make no more progress than a puppy chasing its own tail, or a hen sitting on a pot egg. There are fairly old societies where the present-day contributions could easily have been made fifty years ago. Such Papers as the managing committee of the research association release for publication will act as a leaven on the various contributions to the society, and make for progress.

About 15 years ago I drew up a programme of research for the refractory materials industry. The chairman predicted at the time that it would take a quarter of a century to do the work outlined in the programme. About a year ago, the programme was reprinted by the council with some encomiums on my foresight, but the way the subjects have opened out during research now suggests that 25 thousand years would be a safer prediction than 25 years for the fulfilment of the programme. This illustrates a very disquieting feature about industrial research; it seems to be impossible to extend our knowledge without at the same time widening the bounds of our ignorance. Even that is all to the good.

The Annual Banquet of The Institute of Vitreous Enamellers in Manchester.

THE CHAIRMAN'S REPORT

Mr. W. H. Whittle (Chairman of the Institute) presented a report to the members as follows:—

The membership has now reached the figure of 185, comprising 84 subscribing firm members, 53 ordinary members, 26 associate members, and 22 associates. This is an increase of 50 members during this year.

The second annual conference, which was held in London in September last, was as successful in every way as the first conference held in Birmingham. This third annual conference has also been well supported, and the attendance at the banquet at the Midland Hotel here in Manchester, though not so good as on previous occasions, has nevertheless come up to our expectations.

There have been good attendances at the visits this morning, both to the Pilkington Tile & Pottery Company, Limited, and Tootal Broadhurst Lee & Company's works, and this winter's season, therefore, has had a good support at its outset.

The second Scottish Conference was held in June last, and was well supported both by the Scottish and English members. This section, which was a little slow in starting, is now going well, and some interesting lectures, to be given in Glasgow and Falkirk, have been arranged during the coming season. Altogether 27 technical meetings were held last year in the four sections, *i.e.*, Southern, Midland, Northern and Scottish, and every meeting was well attended.

This season 25 lectures have been arranged, the programme of which should be in the possession of every member.

Five works visits were organised last year, and these were by courtesy of W. & T. Copeland & Son, Limited; Carborundum Company, Limited; Norton Grinding Wheel Company, Limited; Midland Electric Manufacturing Company, Limited; and Armco, Limited, all of which were well attended.

Further works visits are now being arranged for this season, three of which have now been definitely fixed, one to the Gramophone Company, Limited, Hayes, Middlesex, on December 10, the second to John Harper & Company, Limited, Willenhall, on January 23, and the third to Brayshaw Furnaces & Tools, Limited, on November 12.

The second "Annual Proceedings" has been distributed to the members within the last few days. This publication, it will be seen, is a little more ambitious than was Volume 1. It is hoped that, in time, these "Annual Proceedings" will cover the year's activities entirely.

The revision of Articles of Association, which has been a subject of some discussion at previous meetings, has now been completed by the Sub-Committee concerned in this work, and it remains to be accepted by the extraordinary general meeting. A circular letter has been sent to each and every member listing the alterations which are proposed to be made.

In regard to the registration of the trade sign, this work has been completed, and a certificate of registration has been received only two days ago. Subscribing firm members will receive a circular letter in the immediate future regarding the use of this sign on their enamel ware and any other uses.

During the past year the Institute has undertaken distribution of works on enamelling, amongst which are "Enamels," by Dr. Andrews; "Red Remedier," by Karl Turk; "The Advanced Technique of Porcelain Enamelling," by J. E. Hansen; and a "Handbook on Designing Metal Parts for Porcelain Enamelling." This distribution has been undertaken by Mr. B. B. Kent, chairman of the Southern Section of the Institute, and there has been a general demand for these books.

At the International Foundry Congress held in Düsseldorf this year a visit was made to an enamelling plant in Germany by those members of The Institute of Vitreous Enamellers attending the Congress. The arrangement for the party was kindly made by Mr. V. C. Faulkner, for which the Institute are indebted, and the visitors to Düsseldorf have been most enthusiastic about their reception, and the interesting work seen.

The Council has had under discussion for some while past a scheme for obtaining laboratory facilities for the members of the Institute, and it has been suggested that we might co-operate with the British Cast Iron Research Association in this connection. When the Council has completed its work in pursuing this scheme, the members will be informed when and how the service can be utilised.

The Institute of Vitreous Enamellers is being represented on the Technical Committee PW/52 Road Traffic Signs recently inaugurated by the British Standards Institution.

A further matter which has been under discussion is an official visit to the United States. Further particulars will be forthcoming very shortly, and it is hoped that those members who can arrange to go will support the party. The Council can then get in touch with the Ceramic Society or the Porcelain Society of America on the matter.

Another scheme that is on foot is the arrangement for classes at technical schools for vitreous enamelling. The Council has been in touch with the educational authorities in various centres, and it is hoped that these will be given support by junior members of enamelling concerns.

Another point to mention is that, thanks to the efforts of our President, the English Ceramic Society, at their next meeting, are going to discuss arrangements for the holding of technical lectures in connection with pottery materials, heavy clay materials and vitreous enamelling, and this will be a means of bringing the two organisations closer together.

The Council of the Institute is endeavouring at every opportunity to explore fresh avenues which will be of interest and of use to the enamelling industry.

The Council would like to place on record the thanks of this meeting to the Northern Committee, which has had the arrangements for this Conference in hand, and particularly to Mr. H. Bradley, who has done the bulk of the work.

A vote of thanks was unanimously accorded to the Northern Committee and to Mr. H. Bradley for the highly successful way in which they had made the arrangements for the Conference.

Mr. H. Bradley, in acknowledging the vote of thanks, said that he, personally, felt that it had been to a certain extent an honour to bring together so many members from the Midlands and the South.

Progress of the Institute

The President, Dr. J. W. Mellor, mentioned that someone had asked him that morning what he thought concerning the progress of the Institute. He thought that it had made marvellous progress during the three years it had been in existence. He had seen other societies grow, but he had never seen one grow more enthusiastically.

A Paper entitled "Modern Tendencies in Vitreous Enamelling" was then read by Mr. S. Hallsworth, which was followed by a long and interesting discussion. A full report of the Paper appears in this issue of The Foundry Trade Journal, whilst the discussion will appear subsequently. Upon the motion of Mr. Grainger (Burton-on-Trent) a unanimous vote of thanks was accorded to Mr. Hallsworth for his interesting Paper.

EXTRAORDINARY MEETING

An extraordinary meeting of the members of the Institute for the purpose of considering the revision of the Articles of the Association was then held, Mr. W. H. Whittle being in the chair.

The Chairman said that copies of the proposed alterations had been circulated, and no doubt the members had given them due consideration. The idea of a revision arose at a meeting held some twelve months previously, when it was felt that there should be some method adopted for the retirement of the members of the Council and of officials annually. The original Articles did not specify that any given number should retire, and it was now desired to make them a little more up to date. At the formation of the Institute various Vice-Presidents and others had been appointed, and they had now been eliminated in accordance with the provisions of the proposed revision. A definite number would retire each year.

Another point was that the date of the general meeting could be altered, the members of the Council being of the opinion that it should coincide with the date of the annual conference. According to law, being a limited company, limited by guarantee, they were bound to have a meeting every year or in not more than 15 months. The annual conferences had been held at the end of September or the beginning of October, while the financial year ended in April, thus necessitating a different date for annual general meeting from that of the annual conference. If the proposed revision of the Articles of Association was approved at that meeting, then the matter would be brought forward at the next annual general meeting, which would be in April, for ratification. The payment of the annual subscriptions would not be affected, but there would be a simplification in the making up of accounts and a compliance with the legal requirements.

Mr. J. H. Coupe (London) inquired whether 21 days' notice must be given to every member of the Institute before any amendment could be made.

The Chairman stated that such a period was not set forth in the Articles of Association.

The Chairman then read the proposed alterations, as contained in a circular letter, as follows:—

Notice is hereby given that an Extraordinary General Meeting of the members of the Institute will be held at Room 108, Midland Hotel, Manchester, on Saturday, the third day of October, 1936, at 4 o'clock in the afternoon, when the following Resolutions will be submitted to the Meeting as Special Resolutions:—

"That the Articles of Association of the Company be altered as follow:—

(1) That Article 14 of the said Articles shall be deleted and the following new Article inserted in lieu thereof—

14.—A General Meeting of the Members of the Institute shall be held in every calendar year on such day not being more than fifteen months after the holding of the last preceding General Meetings as the Council shall appoint. All such Meetings shall be deemed to be Ordinary Meetings and all other meetings shall be called Extraordinary Meetings.

(2) That Articles 28, 29, 30, 31 and 37 shall be deleted and the following new Articles be inserted in lieu thereof—

28.—The Council shall consist of eleven Ordinary Members of the Institute, comprising a President, Honorary Treasurer, and not more than nine ordinary members. In addition, the Chairman and Secretary of each branch or section of the Institute shall be *ex-officio* members of the Council. No member who or whose firm is engaged in or associated with the manufacture or supply of plant, apparatus or raw materials used in the vitreous enamelling industry shall be eligible to serve on the Council.

29 (*a*).—The President of the Council and three of the ordinary members of the Council shall retire from office at each Annual General Meeting of the Institute.

(*b*) The ordinary members of the Council to retire in every year shall be those who have been longest in office since their last election or appointment, but as between persons who became or were last re-elected ordinary members of the Council on the same day, those to retire shall (unless they otherwise agree among themselves) be determined by lot.

30.—The Honorary Treasurer shall retire at the Annual General Meeting next after the expiration of three years from date of his appointment, but shall be eligible for re-election.

31.—The Council shall from time to time be entitled to appoint an Ordinary Member of the Institute to fill a casual vacancy in the Council howsoever caused. The person so appointed shall hold office until the Annual General Meeting of the Institute next after his appointment, and if such appointment shall be confirmed by such Annual General Meeting, then such person shall hold office for the same period and upon the same terms as his immediate predecessor would have been entitled to hold the same had he remained in office.

37.—The Council may delegate any of their powers to Committees consisting of such Member or Members of the Association (other than Members who are ineligible under Article 28 to serve on the Council) as they think fit. Any Committee so formed shall in the exercise of the powers so delegated conform to any regulations that may be imposed upon them by the Council."

On the motion of Mr. J. H. Coupe, seconded by Mr. V. C. Faulkner, the proposed revision was unanimously approved.

The Position of the Suppliers

Mr. W. Todd (Birmingham) said that now the revision had been sanctioned he wished to state that he had had an opportunity of discussing the matter with one or two of the members. He found that there was a feeling abroad that the Council had some ulterior motive in the step they had taken. It had been construed in certain quarters that they were actuated by some animus towards their *confrères* who were on the supplying side. He thought he would perhaps be in order, at this stage of the proceedings, in assuring their friends on the supplying side that such an impression was entirely wrong. No such feeling existed among the members on the Council. They all owed a deep debt of gratitude to their friends on the supplying side. Without their active co-operation and support, the Institute could not have served its full and useful purpose. He wished to take the opportunity of removing any doubt from the minds of any members or representatives of supplying firms that there was any ulterior motive whatever behind the proposed alterations. The clause was inserted in the original Articles of Association, and it had not been altered. The point was fully outlined at the inaugural meetings. Reiteration was unnecessary. They all welcomed the co-operation of their friends on the supplying side of the business.

The Chairman was very glad that the point had been raised by Mr. Todd. He wished to confirm everything that that gentleman had said. There was no ulterior motive on the part of the Council in any way whatever. The matter was thoroughly threshed out in the first instance, and was raised chiefly from the suppliers themselves, who thought it was best that they should not take office. The Institute desired their hearty co-operation in every way possible, and without their assistance it would not be able to function as well as it did.

In conclusion, the Chairman stated that the visit to America would probably take place in September next year. Ten days would be spent in the country, so that the whole trip would last about three weeks. About 15 members signified their intention of considering the possibility of taking the trip.

On the following morning, Sunday, October 4, about 20 members of the Institute visited Llangollen, in North Wales.

MEMBERS ATTENDING CONFERENCE

The following is a list of members and guests who attended the annual conference:—

W. Astles, F. W. Baber, C. J. Baines and Mrs. Baines, — Baker and Mrs. Baker, W. Ball and Mrs. Ball, Miss Bates, H. A. Bore and Mrs. Bore, H. Bradley, J. H. D. Bradshaw, D. Burton and Mrs. Burton, H. W. E. Butcher, G. C. Clayton and Mrs. Clayton, Miss Clendon, W. B. Cleverly, J. H. Coupe, A. W. Coupe, — Cumberland, J. H. Davidson, Miss Dove, Miss M. Elliot, A. England and Mrs. England, J. Fallon and Mrs. Fallon, V. C. Faulkner and Mrs. Faulkner, A. L. Fawkes and Mrs. Fawkes, W. S. Grainger and Mrs. Grainger, J. H. Gray and Mrs. Gray, Miss P. Greenwood.

S. Hallsworth and Mrs. Hallsworth, H. B. Handcock and Mrs. Handcock, H. Heath, J. Herd, H. W. Higson and Mrs. Higson, K. Hill and Mrs. Hill, L. Holt, J. H. Hollows and Mrs. Hollows, W. F. Holmes, Barrington Hooper, C.B.E., W. A. Hooper, J. Hudson, Miss D. R. Jackson, H. Jukes and Mrs. Jukes, B. B. Kent, H. W. Lowe and Mrs. Lowe, W. E. McCalla, B. A. McCalla and Mrs. McCalla, W. Marshall and Mrs. Marshall, K. Marshall, Dr. J. W. Mellor and Mrs. Mellor, Miss Mileson, A. Moorcroft and Mrs. Moorcroft, J. Nicholls and Mrs. Nicholls, — O'Brien and Mrs. O'Brien, — Pardoe and Mrs. Pardoe, J. Pell, — Perslow, C. G. Pettit, — Pickwell and Mrs. Pickwell, Miss Pover, — Praeger and Mrs. Praeger.

S. R. Read and Mrs. Read, L. Redman and Mrs. Redman, S. Rimmer, H. C. Roberts, A. Rodway, R. J. Sharratt and Mrs. Sharratt, D. Sleath, A. J. Somers, A. J. Spittle and Mrs.

(*Concluded on facing page.*)

Modern Tendencies in Vitreous Enamelling*

By S. HALLSWORTH

The author proposes to survey the developments of the past 10 years, and especially the latter portion of this decade, in regard to the considerable improvements that have been made in both technical and practical aspects relative to the vitreous enamelling industry. By this is meant the application of enamel to sheet and cast iron utilised in the manufacture of domestic appliances.

A new stimulus to research combined with the exploitation of an improved method of processing was provided by the advent of British firms interested in the application of enamel on cast iron by what is known as the "wet process." Several manufacturers took part in the initial pioneer work, and the company with whom the author is associated exhibited one of the early cast-iron enamelled cookers at the British Industries Fair at Castle Bromwich in 1928. This was favourably commented upon by their Majesties the late King George V and Queen Mary when they honoured the Exhibition by a visit; they expressed on that occasion their delight at what they felt would no doubt be a boon to housewives.

Tremendous strides have been made by all concerned in the industry and this acceleration has been made even more manifest during the past five years. In particular, a remarkable interest has been shown in regard to the utilisation of mechanical aids to production in the interests of lower costs.

Possibilities of Mechanisation

Vitreous enamelling does not lend itself to mechanisation so easily as many other processes. It is difficult to imagine a machine or combination of machine units whereby the ware can be inserted immediately after fabrication and will come out at the other end finished in, say, coloured mottle or two coats of white with neat black edges, to say nothing of the incidental transfers that one has to affix nowadays.

However, continuous pickling, automatic spraying, continuous drying and fusing all help to make even this high ideal capable of accomplishment, and it would not be stretching the powers of imagination too far to visualise in the near future a Robot-like machine unit of this description. Even with the present stage of mechanical development enamellers have obtained a partial elimination of the human element, increased production and consequently reduced costs.

This has, of course, entailed the insistence upon a more rigid control of the composition and application of the enamel and of the various processes throughout the enamelling plant.

The most important modern tendency which affects everyone engaged in the vitreous enamelling industry, and without which the details outlined in this Paper would not have been possible, is the rapidly increasing use of vitreous enamelled products. In this country there are vitreous enamelled signplates, gas and electric cookers, refrigerators, wash boilers, wringing machines, coal ranges, domestic ware, even the more modern Belisha Beacons and roadsigns, whilst in America one now finds porcelain enamelled houses, shop fronts, and petrol stations, to mention only a few of the modern uses to which the industry's products are put.

As a young man in the industry the author feels some trepidation in presenting a Paper of this description in the presence of so many older in years and experience. If, however, it contains any statements of a provocative nature (as is believed by the author), which will stimulate a discussion, no doubt great benefit will be derived from the latter if not from the Paper itself.

The two main avenues of development in any industry in the interests of lower costs are:—

(1) Aids to increased production per operator per hr.

(2) To reduce the cost per unit weight or area of the finished product.

Modern developments in the vitreous enamelling industry can be summarised under five main headings:—

(*a*) The enamel itself.
(*b*) Preparation of the metal prior to enamelling.
(*c*) Application of the enamel and drying of the enamelled ware.
(*d*) Furnaces and equipment.
(*e*) Control.

It is not proposed to deal with all of these in detail, for during the forthcoming session several lectures are to be given by experts which will discuss many of these suggestions more fully.

THE ENAMEL

The earliest jewellery enamels were of comparatively simple composition, some containing the oxides of only silicon, potassium, lead and boron. With the introduction of sheet and cast iron enamelling, alterations had to be made in the enamel composition. Further modifications in the formula had to be made with the advent of the "wet process" as applied to cast iron, and a considerable amount of research work has and will continue to be carried out on this subject.

The early wet-process enamels for cast iron contained lead oxide in large quantities. Owing to the attitude of the Home Office and the various health and medical authorities it became necessary to eliminate the lead oxide. This is one important aspect which shows an advantage our confrères in America possess. The presence of lead oxide makes for ease in processing, and the restriction explains to a certain extent the difficulty that American suppliers have had in introducing enamels into this country. It also affects the technique appertaining to other subsidiary processes.

It is also important to bear in mind, when comparing American and British practice, that in many of the appliances produced in this country a far greater amount of cast iron is used than in the American products, although there is a definite tendency in this country to introduce sheet iron and eliminate cast iron.

Extensive research work was necessary before satisfactory leadless enamels for this purpose were produced. During the past few years demand has been made for an enamel which has not only an attractive appearance but which will withstand the chemical action of the various acids encountered in the kitchen. Special enamels of high acid resistance were developed, but these were difficult to manipulate and were only suitable for certain articles. The ultimate aim of all enamel manufacturers was to produce a low-temperature-fusing acid-resisting enamel, and therefore the silicon content had to be reduced from the high amount present in the former acid-resisting enamels. This also involved a reduction in the borax content in order to maintain the acid resistance. Such chemicals as sodium silicofluoride, sodium-mentantimoniate, titanium and zirconium oxides were incorporated in the enamel to give both fusability and resistance to acids. Low-temperature-fusing acid-resisting enamels for application direct on to cast iron are now being produced, but these developments have resulted in an enamel of a very different composition.

Present-day enamels are of a complex mixture of the oxides of silicon, aluminium, sodium, potassium, boron, calcium, barium, magnesium, zinc, antimony, titanium, zirconium; also fluorine and, in the case of the black frits, cobalt, manganese and nickel oxides. These developments have all been accompanied by alterations in the methods of application.

Research work is still being carried out on white ground coats or white enamels which can be applied direct on sheet iron. These will also require modifications in the application and processing of same.

Manufacture

In the early days the raw materials were of variable quality, roughly weighed, usually mixed by hand and smelted in direct coal-fired smelters. The shortcomings of the old-type smelters were numerous: dirt, lack of uniform temperature, and variation in the composition and physical properties of different batches of enamel, being only some of the defects encountered.

At the present time, raw materials are mainly of reputable quality. They are accurately weighed and in some cases special scales are used which record the actual weight of material taken. Mechanical mixers of various designs are on the market, these giving the materials a thorough mixing, which results in reduced time of smelting and aids the development of uniform colours and opacity.

Most modern smelting furnaces, whether of the static or the rotary type, are fired by means of oil or gas. Pyrometric control of the temperature of melting can be adopted, these improvements resulting in a clean frit of uniform quality.

Milling

Considerable investigations have been made in the operation of grinding mills, and the modern practice of enamel milling has been outlined in a Paper read to members of this Institute. Some of the modern methods are rather revolutionary, but there is no doubt that their adoption results in the production of a more uniform enamel in larger quantities than were previously obtained.

The fitting of revolution counters on the mill makes it possible for the mill to be run for a definite number of revolutions instead of a number of hours which took no account of "belt slip," etc. The adoption of this device and the use of water meters, which register the number of gallons rather than the number of buckets which are filled in a more or less haphazard manner, have been definite steps in the accurate control of a most important department of the enamel plant.

The screening of the enamel was previously carried out by hand, but the flat reciprocating screen has considerably increased the output per man per hour. The rotary type of screen would appear to be gaining favour, increased production being claimed for this type over the flat screen. In the rotary screen the enamel slip is

Members Attending Conference

(*Concluded from previous page.*)

Spittle, C. P. Stone and Mrs. Stone, R. Stubbs, M. D. Thompson and Mrs. Thompson, G. L. Thompson, W. Todd, — Tomkinson, A. V. Vale and Mrs. Vale, S. W. Vickory and Mrs. Vickory, F. Waterhouse, T. L. Wenger, H. Whitaker and Mrs. Whitaker, W. H. Whittle and Mrs. Whittle, H. W. Whittle and Mrs. Whittle, R. W. Whittle and Mrs. Whittle, H. G. Williams and Mrs. Williams, F. W. Wilson, H. Winterton and Mrs. Winterton.

* Paper read at the Third Annual Conference of The Institute of Vitreous Enamellers at Manchester, October 2 to 4, 1936.

fed into a funnel at the upper end of a shaft, down which it runs to a rapidly revolving spray-head. The centrifugal force of the spray-head throws the slip in a fine spray through the screen surface. The portion of slip which does not pass the screen flows down into the residue tank, where it is picked up by the revolving cone and again thrown into the screen. Magnetic separators are also a modern addition to the mill-room equipment, and the use of these developments will result in less trouble during the enamelling proper and will produce a much more satisfactory article.

PREPARATION OF METAL PRIOR TO ENAMELLING

Cleaning Sheet Iron

The older method of grease burning prior to pickling is a rather expensive one, and the iron oxide formed during the process retards the speed of pickling. Where production warrants it, the introduction of a trichlorethylene degreaser or chemical cleaner will be found of considerable benefit, both from a production and economy standpoint.

These processes effectively remove oil or grease from the ware and leave the iron in a clean state, free from iron oxides. A considerable reduction is effected in the amount of handling, for the ware, as it is received from the fabrication department, can be loaded into baskets and does not require handling again until it reaches the grip-coat dipping section.

Trichlorethylene Degreasers

There are two main types of degreasing plants:—(1) vapour only, and (2) vapour and liquid.

The vapour type consists of a tank of suitable size, containing a sump at the bottom and a coil containing running cold water near the top. The sump is filled with trichlorethylene and the temperature raised to boiling, which is incidentally only 87 deg. C., and a clear vapour is given off. A very suitable method of heating is by a thermostatically controlled gas-burner underneath the sump, although steam, oil or electricity can be used as a heating medium. The warm vapour which is given off condenses to liquid on the cold metal surface, dissolves the grease and falls back into the sump.

In the liquid and vapour method the plant is divided into two compartments, one for liquid and one for the vapour principle. The condensate from the vapour section runs into the liquid compartment, which overflows into the main sump. With this method any very greasy parts are washed in the liquid and then transferred to the vapour section.

Chemical Cleaner

The chemical cleaner process consists of a tank, usually made of iron or steel, of the capacity required by the nature and size of the work. The tank may be heated by steam coils and a vertical metal plate extending to the ends of the tank, but only to within six inches of the bottom, will aid the circulation of the solution.

The cleaning compound consists mainly of sodium carbonate, sodium hydroxide, sodium phosphate and resin, along with the water of crystallisation. A 3½ to 4 per cent. solution is usually made at the commencement of the operation. The solution should be tested daily. This may be done by titration, the amount of sodium oxide being calculated and used as a basis; or special pills are obtainable which eliminate the necessity for chemical titration. Whichever method is adopted, testing must be carried out daily and sufficient compound added to maintain the solution at standard strength.

The conveyor or semi-conveyor system has been one of the latest developments in the vitreous enamelling industry, and in no part of the plant does it give more benefit than in the pickling department. The system can be of the intermittent or the continuous type.

The hand-operated intermittent system requires—in addition to the Monel Metal pickling baskets—the various tanks to be in line, and a mono-rail to be installed above the full length of the tanks and drier; also from the outlet of the drier to the grip-coat dipping tanks and from this point back to the loading stage in the pickling shop. Two mechanical hoists are desirable for speed in lifting and lowering the basket, which is immersed in the various liquids for the requisite time to complete the various processes. With this system the only actual handling of the work is the loading and unloading of the baskets, and two men could easily and effectively degrease and pickle 800 to 900 sq. ft. of sheet-iron parts per hour.

With the continuous process the ware to be cleaned is placed in baskets which are attached to a conveyor. The conveyor chain and rails are so arranged that the baskets are automatically lowered into the various tanks and passed through the solution at a pre-determined speed. The speed of travel of the conveyor is so arranged to permit of the given time of immersion in the various solutions, and the size of the tanks is also varied accordingly. If desired, the chain can be operated intermittently, *i.e.*, a certain length of time moving and a certain period stationary. This latter method eliminates the use of large tanks.

Preparation of Cast Iron

Considerable improvements have been effected during the past few years in cleasing the surface of cast iron components prior to enamelling, and here also the tendency has been towards mechanisation.

If one passes in review the stages from the early days when wire brushes and abrasive slips were used for the purpose of cleaning and rubbing down the surface of cast iron; the introduction of sand-blast rooms and cabinets using flint as the abrasive with its attendant defects; the dust-laden atmosphere and the tendency for operatives to develop silicosis, the need for improvements in technique and equipment will be fully appreciated.

The introduction of angular steel abrasives provided the means and incentive for promoting the necessary research work, particularly having regard to the design of equipment. It is true that, as far as this country is concerned, the change-over to the use of steel abrasives was urged by the national health authorities, who sought and obtained the collaboration of leading manufacturers, both parties being desirous of improving the health condition of the operatives and to get better service from the point of view of the enameller.

This has brought about a revival in the design and type of machines. It is worthy to note that as far back as 1893 centrifugal wheels were used for the operation of sand-blast machines, but this was discontinued mainly owing to the rapid disintegration of the quartz sand; but with the use of steel abrasive it has been deemed possible to reintroduce the centrifugal unit.

It is thought by the author that the members of the Institute are entitled to say that this is one of the numerous instances where the Institute and its members, by virtue of the meetings they have held, have created benefits not only to members, but to the industry in general, because it has stimulated development in respect of apparatus of this type. The discussions at earlier meetings held under its auspices and the severe criticisms that were directed against the then existing abrasive shot-blasting machines do certainly seem to have stimulated the manufacturers into taking action. Thus, during the past three years, barrels and revolving tables have been redesigned to allow the introduction of centrifugally-operated units, thus eliminating the use of compressed air, which has always been a very costly item, and effecting large economy in power and operating cost.

APPLICATION AND DRYING OF ENAMELS

Grip-Coat Dipping and Drying

The development in the grip-coat dipping process has been very slow compared with other operations. Many plants still use the same methods that were used thirty or forty years ago, the only variation being the method of drying.

The use of a conveyor combining the dipping, draining and drying is beyond doubt a considerable improvement over the old system, where these operations were carried out separately, and a development of this nature is not entirely confined to what is generally termed "mass-production lines" because the carriers can be adapted to carry a variety of articles, of widely different sizes and shapes.

A conveyor of this type consists largely of a chain to which carriers are attached at definite distances according to the type of work being processed in a given plant. These carriers are fitted with spikes and/or strands of wire by means of which the ware is carried or suspended. The position of the spikes is determined by the type of work and can be so arranged that one large piece or several small ones can be loaded on one carrier. It has been found that the enamel can be dried in 2½ minutes, which conveys some idea of the economies that can be effected.

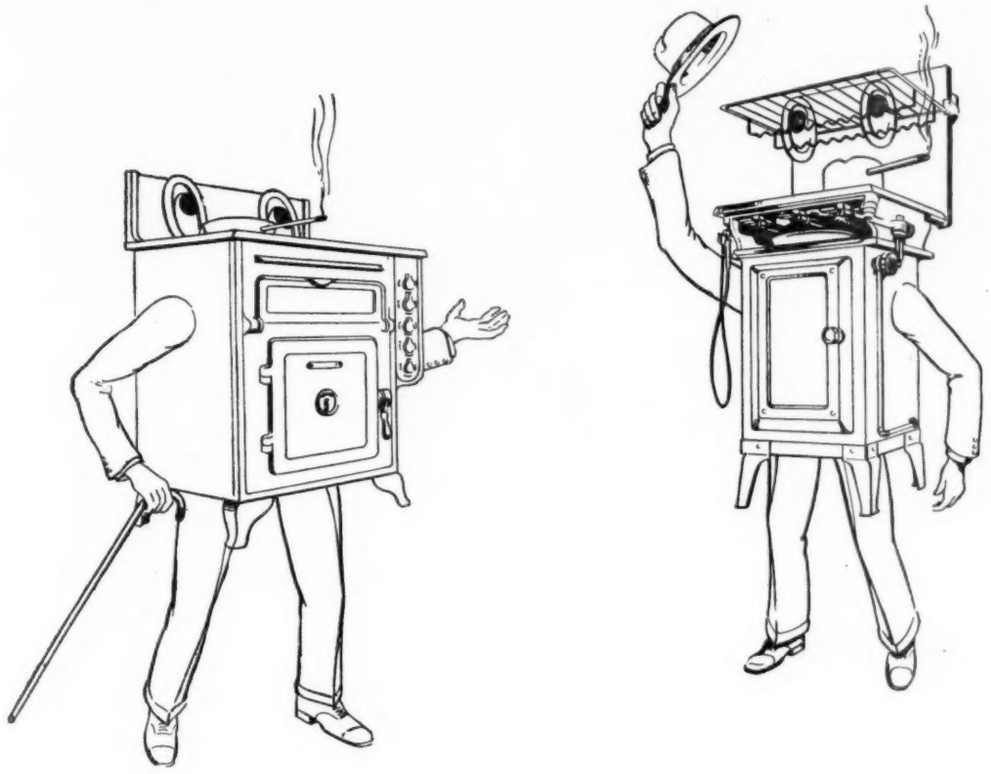
The drier in question is heated by gas burners inside the drier, and by recirculation of the products of combustion complete utilisation of heat for the unit is obtained. The ware is dipped in the usual way and either hung or placed on supports. If it is necessary to reinforce the edges of such articles as cooker splashplates, this can be done immediately after the plate leaves the drying zone and before removing from the conveyor, by the introduction of a spraying unit on the line.

With this process, one man can swill 700 to 1,400 pieces (1,000 to 1,500 sq. ft.) of sheet-iron parts per hour, depending on the type of work being swilled. Until recently it was said that it took months to train a grip-coat swiller and some enamellers have gone so far as to say that good swillers are born and not made. With this process little or no training is required, it being necessary only for the operator to know the correct way of placing the work on the conveyor. The conveyor itself and the enamel control official will do the remainder.

Spraying Plants

There has been a steady improvement in the design of spray guns, but the author thinks that the right method of advantageous exploitation has been in the direction of automatic and semi-automatic spraying and drying plants. Several of these plants have been installed, while they are extensively used in America. One of the installations in this country has four spraying booths attached to a gas-heated drier running from end to end of this continuous unit, and five endless cables are provided for carrying the work.

This plant can be operated by two or four sprayers, depending on the amount of work to be processed and the speed of travel. The ware to be sprayed is placed on the cables just before the first spray booth. The first sprayer covers the flat portion in one direction, and in the case of flanged work, one end and one side. The second sprayer covers in opposite direction, the opposite end and side. With four sprayers the procedure is duplicated, or in some cases three operators can be used, depending on the shape of the pieces. The plate then passes through the drier, edges are brushed where necessary and the work is ready for fusing. One important advantage of this method is that the plate is under cover from the time it is sprayed until it is dried, thus preventing any dust from settling on to the enamel whilst it is wet. Using three sprayers the plant is capable of giving 300 pieces 2 ft. by 18 in. per hr.; with small-sized plates this could be doubled.



GAS COOKER "I say, don't you look well!—all spick and span and a face like a mirror—not a pimple or blemish to be seen. 'BLYTHE' ENAMEL, I can plainly see."

ELECTRIC COOKER "I was just going to pass the same remarks about you old man, and what about the new Acid Resist finish? It is simply splendid—no fear of losing our polish now, and, by the way, what a fine extension they are making at the Works to meet the increasing demands."

Blythe Enamels

BLYTHE COLOUR WORKS LTD · CRESSWELL STOKE-ON-TRENT

'Phone: BLYTHE BRIDGE 101, 102 & 103 'Grams: BLYCOL, BLYTHE BRIDGE, STAFFS.

Depots—
Brussels (Belgium). Turin (Italy).
Gorssel (Holland). Czestochowa (Poland).

Depots—
East Liverpool (U.S.A.). Onda (Spain)
Oporto (Portugal). Teplitz Schonau (Czecho-Slovakia).

The incorporation of mechanically-controlled spray guns in this type of plant is possible if desired. Spray guns mounted on angle brackets and carried upon an overhead transverse gantry may be fitted where existing spray booths are situated. These would be fed by means of an automatic feeder attachment from pressure-controlled enamel containers. The transverse movement could be effected by the use of pneumatic cylinders operating cam-action control-levers attached to the spray guns. This method has been used very successfully on flat work, but difficulties may be experienced where plates with turned-up edges are required, such as cooker crown-plates, etc.

Several conveyor-type driers are in operation, one of the simplest being a box-type drier with a runway on the floor level. The ware after spraying is placed on the rack and then moved through the drier by a conveyor chain fitted with lugs. It is doubtful if this system could be utilised for enamels applied direct on cast iron, as rust spotting might occur. A better system consists of a number of baskets suspended from a conveyor chain. The baskets are designed with arms on which frame castings are hung and flat castings are placed on a tray underneath. On the baskets where there are no arms fitted, three tier trays are used, which are designed to reduce marking of ware to a minimum. This plant will dry 2,200 castings in a shift of 8½ hrs.

FURNACES AND EQUIPMENT

(a) Furnaces

Perhaps no section of the enamelling plant has undergone more changes in design and method of heating than the fusing furnaces. It is a long step from the old direct-coal-fired muffle to the present gas and electrically heated ones.

The coal-fired furnace with the combustion of the coal taking place in the fire box and without methods of recuperation was a very uneconomical unit. The worst feature was the absence of uniform heating and the difficulty of proper temperature control. The temperature of the muffle had to be allowed to rise before the fire box could be cleaned and temperature variations throughout the day ranged from 20 deg. to 60 deg. C., and in some cases even more.

With the demand for furnaces which could be more easily controlled a large number of plants were changed over to oil-firing. A well-designed oil furnace can be properly controlled and an even temperature maintained for a considerable period. This, of course, does not include the fall in temperature when a load is put into the muffle, or the subsequent rise, but the actual temperature at which the enamel is fused.

Unfortunately for those enamellers who had installed oil-fired furnaces the price of oil increased and with the imposition of the Government tax of 1d. per gallon it speedily became evident that the cost of production would be greatly increased. Moreover it was discovered that the refractories did not withstand the products of combustion from crude oils so well as they did when coal was the fuel.

In the meantime considerable strides had been made in the coal-fired furnace. In the present coal-fired furnace, the coal is gasified in a separate though "in-built" producer. The gases meet the requisite amount of air which has been preheated in the recuperator and the mixture is burned at the place where the heat is required, that is, in the combustion chamber. By closely regulating the amount of secondary air and the positions where the air joins the gases from the producer, uniform temperature can be obtained and a well-designed coal-fired producer-type furnace will give equal efficiency and requires little more control than many oil-fired furnaces and is much more economical. Purely from the enameller's standpoint, the gas-fired or electrically-heated muffle would appear to be the best and most efficient. In this case not only is perfect and quick control of temperature possible but automatic devices can be adopted which eliminate the risks run by relying too much upon the human element, which is always a variable factor. A second advantage is that there is regularity in the heating medium, gas of practically constant calorific value being always available. No storage space is necessary for the fuel, and there are no ashes to be removed. This method of heating also ensures the entire absence of dirt. One example of gaseous firing consists of a series of flues round the muffle, each fitted with a separate gas burner. The products of combustion pass through the flue, along the bottom of the muffle, up one side, over the top and down the other side. From here, they pass into a recuperator situated below the furnace and out to a main flue at the back.

Despite all these improvements, furnaces have still certain deficiencies. The heating is carried from outside the muffle or partly outside, which does not give maximum efficiency. Sooner or later cracks appear and products of combustion enter the muffle chamber, which is, of course, most undesirable. One system which would appear to be an improvement has been developed as a research project of the American Gas Association. In this muffle the combustion chambers have been replaced by radiant tubes which are actually inside the muffle itself. Great efficiency is obtained by reason of the high radiant heat of these internally fired tubes and the close proximity of the work to the source of heat. Six hairpin-type radiant tubes are used, four being on the furnace hearth (which also act as supports for the work) and one on each side wall. The tubes are fired from the back by special burners. The tubes are at all times under negative pressure or suction. This is produced by injecting air into a small stack or eductor at the end of each tube. The maximum temperature inside the tube does not exceed 1,000 deg. C. to give a furnace a temperature of 870 deg. C. Repairs can be carried out without in any way interfering with the muffle itself, and can be finished in much less time.

The continuous type of furnace which is so popular in America has not yet found favour in England. This is mainly due to the high initial cost and a fear that this method of fusing would not justify the expense, but personal opinion is that, once a plant has been established in this country, many more will follow. One has only to consider the increased production resultant from the introduction of conveyor methods in any industry to realise the benefits which must inevitably accrue from this method of fusing. The reduced amount of handling, with the inevitable marking and damage, along with the benefits which are derived from the slow cooling of sheet-iron enamel ware, make this project worthy of consideration.

(b) Furnace Equipment

Furnace equipment has also received considerable attention in recent years. One of the most important developments is that of heat-resisting metals for carrying the ware during the process of fusing. Scale from the bars, once such a bugbear in producing white work, has been eliminated, and it has been made possible to produce various types of equipment to increase the production per muffle per hour, at the same time as improving the finished ware.

Hanging of the ware to be fused has been very widely adopted in this country. This method of fusing, which is suitable for both castings and sheet metal parts of suitable design has increased production and effected considerable economies. Double-decking of the ware has also been adopted. Difficulties have been encountered, however, in the general adoption of double-decking and the leaning method is more advantageous when dealing with work that cannot be hung.

With suitable apparatus there is no difficulty in fusing either cast iron or sheet-iron parts without warpage or damage. This method of fusing results in a large increase in the output of the muffle, with little extra fuel consumption. The use of special unloaders will materially assist production on flat ware. The unloaders consist of a number of equally spaced arms to go between the fusing perrits. These arms can be made of 1½ in. T iron or 1 in. steel tube and supports which are fastened to the ground. The lifting or lowering movement can be adapted to the arms or a parallel lift-charging fork can be used. Only one fork and one set of perrits are required. The unloaders are fixed at each side of the muffle. The work to be fused is placed on one set of bars. The charging fork with perrits is run over to opposite the unloader and the work transferred from perrits to bars. In the meantime another load of work has been loaded on to the bars and dusted ready for picking up.

By this means the bars are kept hot as they are only out of the muffle for approximately 45 secs. The use of hot bars is beneficial in sheet-iron fusing, and the use of this apparatus increases the output of the muffle by 25 to 30 per cent.

CONTROL

Success or failure in enamelling practice depends to a large extent on the control and supervision. Although mechanical units make this absolutely essential, considerable benefits can be obtained by intelligent use of control methods and equipment. The installation of recording pyrometers, and their examination by the man in charge of the department will ensure the work being fused at the correct temperature and also enable a check to be made on the amount of production through the furnace.

The tendency at the present time is the adoption of piece-work rates of wages to the employees. Controversy exists as to the advantages to be derived from this method of payment, but the benefits which accrue are most helpful in the control of the department. Not only does it show any weakness in the various serving departments, but the fact that the operator is only paid for all good work passed by the inspector has a more beneficial result than reprimand. In the author's experience it not only gives an increased output but it improves the standard of work from the operator.

Control of Enamel Slips

For many years the enameller had no means of accurately determining the properties of his enamel slips. The mill-room foreman would test for fineness by rubbing the enamel between finger and thumb. The shop foreman, by dipping his fingers into the enamel and watching it drain and set, was able to judge fairly well whether it could be worked or not, but this method leads to complications and uniform results cannot be obtained. Enamel slips do not behave like ordinary liquids and various enamels require different methods of control. Sieve tests are absolutely essential for controlling the grinding time of an enamel.

Several methods are used for testing the consistency of the enamel slip. The flow-test method is very useful for enamels which do not contain an electrolyte. The apparatus is a brass tube 7½ in. long and 1¼ in. diameter. This is tapered at the bottom and contains a small orifice of about 1 to 2 mm. diameter. The enamel is poured into the tube to a certain level and the time in which 50 ml. will run out is determined.

For sheet-iron grip-coat enamels the weight per square foot is more reliable. In this test a piece of sheet iron 17 in. square is pickled and weighed. This is dipped and dried according to standard practice, care being taken that the angle at which the plate is drained is correct, and then reweighed. The difference in weight gives the amount of enamel per 2 sq. ft.

Control methods still leave much to be desired and new and additional methods are under investigation. The control of the thickness of enamel prior to fusing will have a considerable bearing on the enamel rejects both in the shop and during assembly.

(*Concluded on page* 284.)

CUMMING'S BLACKINGS
ARE
THE BEST

Extract from daily report by one of our travellers:—

January 9th, 1936.

Mr. C..... said,

"I shall send on to you every time. Since we adopted your Blacking the skin of our castings has improved by 100 per cent. Our customers were the first to notice it."

NEED WE SAY MORE

All our productions are carefully graded, tested and manufactured.

WM. CUMMING & CO., LTD.

KELVINVALE MILLS, Maryhill, Glasgow, N.W.
SUNNYSIDE BLACKING MILLS, Falkirk.
WHITTINGTON MILLS, Chesterfield.
DEEPFIELDS MILLS, Bilston.
STATION CHAMBERS, Middlesbrough.

The Week's News in Brief

Trade Talk

An order for a 9,000-ton steamer for London owners has been received by John Readhead & Sons, Limited, of South Shields.

An advance of 2½ per cent. in the wages of workers employed in the Scottish malleable-iron trade was made on October 1.

The Engineering Institute of Canada will celebrate its fiftieth anniversary at a meeting in Montreal, to be held from June 15 to 17, 1937.

Negotiations are pending between the British Oxygen Company, Limited, and the Chester-le-Street Rural Council for a factory site at Pelaw Grange.

Edgar Allen & Company, Limited, have appointed Mr. F. W. Perry as a demonstrator for tool steels and general small tools in the South of England.

It is announced that William Beardmore & Company, Limited, Parkhead, Glasgow, are to make the heavy steel castings for the hull of the sister ship to the "Queen Mary."

The estate of Sir John Ellerman, shipowner and industrialist, who died in July, 1933, leaving estate previously valued at £17,224,425, later revalued at £25,817,786, has now been resworn at £36,684,994.

Higgs Motors, Limited, of Witton, Birmingham, announce that they are selling their motors at truly competitive prices in the large cities of America, such as New York and Cleveland, despite an import duty of 35 per cent.

Kingshill House, Dursley, was yesterday presented to the Dursley Rural District Council as council offices by R. A. Lister & Company, Limited, as a memorial to their founder, the late Sir Ashton Lister, on the eve of the firm's 70th anniversary.

The World Power Conference is shortly to publish the first number of the Statistical Year Book of the World Power Conference. This volume will contain an inventory of the industrial power resources of the world, and annual statistics, relating to 1933 and 1934.

R. A. Lister & Company, Limited, of Dursley, have developed the "Listrard" process for communicating an extremely hard surface to Diesel engine cylinders and liners. It carries a chromium surface and extremely long life is claimed. The process is based upon a Dutch patent. Treated components are to be exhibited at the Motor Show at Olympia, London, next week.

The first meeting of the Chemical Engineering Group for the session 1936-37 will take the form of a conference on Automatic Regulators on October 15 and 16 at University College, Gower Street, London, from 3 to 5 p.m. and 6 to 8 p.m. each day. Advance proofs of the Papers will be obtainable from the hon. secretary of the Group at 56, Victoria Street, London, S.W.1, at the price of 5s. per set.

The aggregate tonnage of shipping launched on the Clyde since January 1 is approximately 215,000, compared with about 172,000 for the whole of last year. The returns indicate, however, that the yards as a whole have operated at considerably less than 50 per cent. of their productive capacity. Assuming a fairly steady output in the next three months, the total for 1936 will be approximately 300,000 tons, the highest figure recorded since 1930.

Forthcoming Events

OCTOBER 9.

Manchester Association of Engineers:—Presentation of awards; Presidential Address by Mr. J. A. Thornton, and concert, at the Engineers' Club, Albert Square, Manchester, at 7.15 p.m.

Institute of Metals (Sheffield Section):—"The Trend of Research in Non-Ferrous Metallurgy," Chairman's Address, by Prof. J. H. Andrew, D.Sc., at the Non-Ferrous Section of the Applied Science Department of the University, St. George's Square, at 7.30 p.m.

OCTOBER 13.

Institute of Metals (Scottish Section):—Works visit to Babcock & Wilcox, Limited, at 7.30 p.m.

OCTOBER 23.

Institution of Mechanical Engineers:—Presidential Address, by Sir Nigel Gresley, at Storey's Gate, St. James's Park, London, S.W.1, at 6 p.m.

Institute of British Foundrymen

OCTOBER 9.

Middlesbrough Branch:—Presidential Address, at the Cleveland Scientific and Technical Institute, Middlesbrough, at 7 p.m.

OCTOBER 10.

Wales, Monmouth and West of England Branch:—Social, at the Royal Hotel, Cardiff, at 6.30 p.m.

West Riding of Yorkshire Branch:—"Test Bar Anomalies." Paper by A. W. Walker, at the Technical College, Bradford, at 6.30 p.m.

The Institute of Vitreous Enamellers

OCTOBER 15.

Midland Section:—"Developments of Airless Shot Blasting." Paper by H. Boardman, at Chamber of Commerce, New Street, Birmingham, at 7.30 p.m.

OCTOBER 17.

Scottish Section:—Joint meeting with the Falkirk Section of the Institute of British Foundrymen; "Enamelling Shop Ventilation," Paper by W. N. Howden, at the Temperance Café, Falkirk, at 7.30 p.m.

Personal

Mr. J. T. Henry has been appointed to the post of general manager, and Mr. B. R. Laing to the position of works controller, of Sheffield Steel Products, Limited.

Sir Harold Hartley, F.R.S., has been re-elected chairman of the International Executive Council of the World Power Conference, to hold office until the next plenary meeting.

Mr. Howard T. Stillwell, late sales manager of Leo C. Steinle, Limited, has joined the staff of E. H. Jones (Machine Tools), Limited, as sales engineer in the London territory.

Councillor W. P. Jackson, J.P., chairman of the Manchester Corporation Gas Committee, was on Monday elected President of the British Commercial Gas Association for the ensuing year.

Will

Denny, Sir Archibald, late chairman of Wm. Denny & Bros., Limited, Dumbarton £115,359

Obituary

Mr. J. Sanders, assistant chief engineer, with the National Smelting Company, Limited, Avonmouth, died on September 26.

Brigadier-General Sir Brodie Haldane Henderson died last week, at the age of 67. He was senior partner in the firm of Livesey & Henderson, civil engineers, and was President of the Institution of Civil Engineers in 1929.

Contracts Open

Dunmow, October 12.—Class B spun-iron pipes—19,380 yds. 4-in. nom. i/d, 6,150 yds. 5-in. nom. i/d, 12,180 yds. 6-in. nom. i/d, 5,780 yds. 8-in. nom. i/d; Class C spun-iron pipes—45,510 yds. 3-in. nom. i/d, 9,100 yds. 4-in. nom. i/d, 3,500 yds. 5-in. nom. i/d, 5,450 yds. 6-in. nom. i/d; cast-iron specials—1,513, ranging from 3-in. to 8-in. dia., for the Rural District Council. E. Sandeman & Partners, 15, Victoria Street, Westminster, S.W.1. (Fee £6 6s., returnable.)

Nantyglo, October 15.—Two and a-half miles of 8-in. cast-iron water main, for the Nantyglo and Blaina Urban District Council. Mr. G. R. Jenkins, clerk to the Council, Council Offices, Blaina, Mon. (Fee £2 2s., returnable.)

Southend, November 19.—750-kw. alternator, for the Electricity Department. Mr. A. C. Johnson, borough electrical engineer and manager, Electricity Works, 85, London Road, Southend-on-Sea.

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Estler Irving, Limited, Oxford Avenue, Trading Estate, Slough.—Capital, £7,000. Ironfounders, sheet metal workers, etc. Directors: E. P. B. Estler and M. J. P. Estler.

If Mr. Jas. M. Leatham, of Knock (?), will communicate his full address, the Editor will reply to his letter.

Modern Tendencies in Vitreous Enamelling

(*Concluded from page* 282.)

The author has previously intimated that he would cover a somewhat wide field and must necessarily be brief in regard to details of the various processes mentioned; but it is considered that there is more than sufficient material to develop an interesting and constructive discussion in the period at the members' disposal. Moreover the author would suggest that if any of the members present or those unavoidably prevented from attending would care to write through the secretary, either making a statement regarding their opinions or raising some queries, he would be pleased to reply to the best of his ability.

Pointers for Discussion

It is suggested that attention might usefully be focused upon the following points in the discussion.

Milling.—(1) That the American method of loading the mills, 45 per cent. (by volume) of pebbles and 21.5 per cent. of frit gives an increase in quantity and quality of the enamel slip; (2) that the rotary type of screen has a distinct advantage over the flat screen and that the increased quantity screened does not affect the slip.

Preparation of Metal Prior to Enamelling.—(1) The relative merits of trichlorethylene degreasers as compared with chemical cleaners; (2) that centrifugal units with angular steel abrasives can efficiently clean the castings for enamelling.

Application and Drying of Enamels.—Some enamellers may be very sceptical regarding the claims with reference to swilling, and especially the training of the personnel. Again it may strongly be disagreed that it is advisable to dry grip coat enamel in the space of 2½ min. The advisability of incurring the expense necessary for the maintenance of a rigid control system may be doubted, particularly by those enamellers who have been so fortunate in having such a small percentage of rejects that they still consider that the existing "rule of thumb" method serves its purpose. The author does suggest, however, that to continue with this method is to court disillusionment, and, unfortunately, in the enamelling industry, the cost of disillusionment is sometimes extremely high.

Furnaces and Equipment.—The remarks upon this subject alone should give rise to several expressions of opinion regarding the relative merits of various fuels and types of furnaces. The author has drawn attention to the advantages to be obtained by the introduction of what are termed rapid unloaders. He is aware that some of his associates in the industry have already tried one type of unloader and discarded it as being unsatisfactory, but it is suggested that they have only touched the fringe of the problem and should not be discouraged by initial failures. There is a solution to most, if not all, the problems in the enamelling industry, but it sometimes requires considerable courage to discard or abolish old-time practices and to look upon the introduction of new ideas without scepticism.

Company Reports

Murex, Limited.—Final dividend on the ordinary shares of 3s. per share, making 5s. per share, or 25 per cent., for the year ended June 30 last. The directors have decided to issue the 46,500 ordinary shares at present unissued, thus raising the issued ordinary capital to £600,000.

Stewarts and Lloyds, Limited.—Interim dividends for the half-year ended June 30 at the rate of 6 per cent. per annum on the cumulative first preference stock, at the rate of 10 per cent. per annum on the cumulative second preference stock and at the rate of 5 per cent. per annum on the cumulative third preference stock.

THE "ROCKET" CORE MAKING MACHINES

HELP to . . .

REDUCE COSTS AND MAKE SOUND CASTINGS

for

BRITISH

— STEEL FOUNDERS —
GREY IRON FOUNDERS
MALLEABLE FOUNDERS
NON-FERROUS FOUNDERS

used in the manufacture of—

Electric Cookers. Gas Cookers. Motor Transport Vehicles. Aeroplanes. Internal Combustion Engines. Cast Iron Bath Fittings. Brass Water Service Fittings. Sluice Valves. Gas Valves. Rain Water Castings. Textile Machinery. Lawn Mowers. Ship Building, etc., and General Engineering Castings.

FOUNDRY ENGINEERS LIMITED

HALIFAX — YORKS.

Telephone: Halifax 61459. Telegrams: "FEL," Halifax.

Raw Material Markets

Deliveries of iron and steel continue to be made on a heavy scale, but in some cases they are behind schedule. Makers are working to capacity, and they are not in the position to accept new business, which would involve very large tonnages if supplies were available. Costs of production have been further advanced by the difficulty in obtaining adequate supplies of ore and coke, while the reduction in blast-furnacemen's working hours will also add to makers' expenses. Export trade is not large at the moment, and thus business will not be greatly affected by the devaluation of the franc, which should, however, provide for more stable international trade in due course.

Pig-Iron

MIDDLESBROUGH.—Active conditions continue to prevail in this area, but new business, owing to existing commitments, is at a minimum. Consumers are having only their current requirements satisfied, and no provision can be made for stocks. The latter are at a very low level. Makers continue to refuse to accept export orders, as there is no surplus iron after home needs have been met. Prices, which are almost certain to remain in operation at least till the end of December, are 75s. for No. 3 Cleveland G.M.B., 74s. for No. 4 foundry and No. 4 forge, and 77s. 6d. per ton for No. 1 foundry all delivered Middlesbrough or Falkirk.

Production of East Coast hematite, which is at the highest level since 1929, is fully taken up by home users. Export business can only be accepted at the expense of consumers in this country. Prices are based on East Coast mixed numbers at 85s. per ton for deliveries on the North-East Coast, while export quotations are several shillings below this figure.

LANCASHIRE.—Forward buying in this area is expanding, and deliveries against existing contracts are also on an increased scale. The chief activity is among makers of machine tools, light castings, heavy electrical goods, and various other engineering sections. Offers of Staffordshire and Derbyshire brands of No. 3, for delivery to users in the Lancashire price zone, are all on the basis of 83s. per ton, with Northamptonshire iron at 81s. 6d. and Derbyshire forge at from 78s. to 80s. per ton, according to the class of user. Scottish foundry iron is quoted around 91s., delivered equal to Manchester, with East and West Coast hematite at 93s. 6d. and 93s. per ton respectively, delivered in the Manchester district

MIDLANDS.—The light-castings makers remain active consumers of pig-iron in this area. A meeting of producers was held during the past week, but no alteration was made in prices, which remain at 77s. 6d. per ton for Northants No. 3, and 80s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, all delivered to Birmingham and Black Country stations, and subject to a small sliding-scale rebate to large consumers. A good demand exists for forge pig-iron at unchanged prices. Machine-tool makers, together with the engineering and motor-car trades, are taking up large tonnages of special irons, the prices of which vary considerably. Medium-phosphorus iron is quoted from 82s. 6d. to 90s., low-phosphorus 92s. 6d. to 100s., and refined iron from £6 10s. and upwards. Scottish No. 3 is quoted at 92s. 6d. per ton, all delivered in this area. Heavy tonnages of hematite iron are being inquired for. West Coast mixed numbers are quoted at £4 17s., East Coast at £4 16s., and Welsh mixed numbers at £4 15s. 6d. per ton, delivered Midland stations.

SCOTLAND.—The demand for pig-iron is very heavy, but as makers have already heavy commitments, little new business can be accepted. Imports of both basic and foundry from India have been substantial. The quotation for No. 3 foundry remains at 79s. per ton f.o.t. furnaces, with 2s. 6d. extra for No. 1 grade. Nominal prices of Cleveland No. 3 are 75s. f.o.t. Falkirk and 78s. f.o.t. Glasgow. Activity at the steelworks continues unabated. Prices of steel-making irons are 85s. 6d. per ton, less 5s. rebate, for mixed numbers of East Coast, West Coast and Scottish hematite; basic, British and Indian, 75s., less 5s. rebate, all delivered steelworks.

Coke

Very firm conditions are prevailing on the foundry-coke market, and prices are likely to be increased. For delivery in Birmingham and district, best Durham coke is quoted between 40s. and 42s. 6d., with Welsh from 40s. to 50s. per ton.

Steel

There has been no relief from the stringent conditions ruling in the steel market, although practically all departments of the trade are operating at capacity, says the official report of the London Iron and Steel Exchange. Few of the producing concerns are seeking fresh business, and it is becoming increasingly difficult to place orders for execution within normal periods. In the semi-finished steel department consumers are pressing to obtain deliveries against contracts, and many of the producing works have sold their output for the remainder of this year. The market requirements of finished steel show no diminution, and the productive capacity of the works is being taxed to the utmost. In spite of record outputs, the home demand absorbs a very large proportion of the production, and in some departments consumers complain of the stringent conditions which are developing. Little surplus remains for export, but business with oversea markets shows signs of improving, and recently there has been a good volume of inquiry.

Scrap

There has been renewed activity on the Cleveland market, and new buying is now exceptionally heavy. The price of heavy melting steel is nearer 60s. than 57s. 6d., which has been the quotation for a considerable time, but buyers are reluctant to do business at this level. Machinery metal at 67s. 6d. and foundry cast-iron scrap at 65s. are well taken up. The demand on the Midland market is also good and prices are firm, with a rising tendency. Heavy steel in furnace sizes is at 52s. 6d., and more has been obtained in some cases. Heavy unsheared wrought iron is at 65s., with heavy machinery in handy sizes at 70s., good heavy pipe and plate at 65s., and clean light metal at 52s. 6d. to 55s. Short, heavy, steel scrap, as used in the foundries, is at 65s. per ton, delivered works. Active conditions also prevail on the Yorkshire market. Heavy basic steel for melting is quoted between 57s. 6d. and 60s., but sellers are reluctant to transact business beyond the end of the year. Heavy steel-works cast iron at 55s. receives a good inquiry, while light material is active around 57s. 6d. Foundry cast iron is quoted up to 67s. 6d., according to quality and specification. Consumption of scrap on the Scottish market is satisfactory, and substantial tonnages are changing hands. Heavy steel scrap is at 57s. 6d., with heavy basic, or heavy iron and steel scrap mixed, at 52s. 6d. Wrought-iron piling scrap is around 70s., with special quality from 72s. 6d. to 75s. Good, clean, heavy, machinery cast-iron scrap, in pieces not exceeding 1 cwt., is 69s., with heavy, ordinary cast-iron scrap, to the same specification, 64s. to 65s. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—This market has borne a quieter appearance during the past week following the recent spell of heavy buying, and the tonnage changing hands has been of a distinctly reduced volume. The general tone of the market, however, is still firm and the set-back is likely to be of a temporary nature only. In view of the anticipated rise in the price of domestic copper in the United States some large-scale buying has been transacted. The Canadian output of copper during the first half of 1936 was 102,983 short tons, as compared with 107,378 tons in the corresponding period of 1935.

Daily market prices :—

Cash.—Thursday, £39 13s. 9d. to £39 15s.; Friday, £39 10s. to £39 11s. 3d.; Monday, £39 15s. to £39 16s. 3d.; Tuesday, £39 15s. to £39 16s. 3d.; Wednesday, £39 15s to £39 16s. 3d.

Three Months. — Thursday, £39 15s. to £39 16s. 3d.; Friday, £39 12s. 6d. to £39 13s. 9d.; Monday, £39 16s. 3d. to £39 17s. 6d.; Tuesday, £39 17s. 6d. to £39 18s. 9d.; Wednesday, £39 16s. 3d. to £39 17s. 6d.

Tin.—According to the monthly statistics issued by Mr. W. H. Gartsen (Henry Rogers, Sons & Company), the total visible supply of tin at the end of September was 12,663 tons, as compared with 14,425 tons at the end of August. The carry-over in the Straits Settlements was 2,476 tons, against 1,597 tons, while the carry-over at the Arnhem (Holland) smelter was 833 tons, against 750 tons. The market has been quite firm generally and the demand in this country has increased slightly. Continental users also have substantial requirements, but in the United States the market is rather subdued.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £202 5s. to £202 10s.; Friday, £201 10s. to £202; Monday, £202 15s. to £203; Tuesday, £202 10s. to £202 15s.; Wednesday, £202 to £202 5s.

Three Months.—Thursday, £199 to £199 5s. Friday, £198 5s. to £198 10s.; Monday, £199 15s. to £200; Tuesday, £199 5s. to £199 10s.; Wednesday, £198 15s. to £199 5s.

Spelter.—Although consumption is reported to be on a good scale, buyers are not taking a very active interest at the present time. The outlook for the market is difficult to gauge and much depends on the progress of the Cartel negotiations, which, at the moment it would appear, are in a state of suspense. World production of slab zinc in August, as reported by the American Bureau of Metal Statistics, totalled 136,300 short tons, compared with 138,600 tons in July.

Official quotations were as follow :—

Ordinary.—Thursday, £13 17s. 6d.; Friday, £14 1s. 3d.; Monday, £13 18s. 9d.; Tuesday, £13 16s. 3d.; Wednesday, £13 17s. 6d.

Lead.—Some relief to the shortage of lead supplies will be given by the resumption of operations at the Hoboken smelter. This came as a welcome surprise to the market. While the tone remains quite satisfactory, users are preferring to await events before committing themselves any further. In the United States, cable makers and pipe and sheet concerns are actively employed. World production of lead during August, as reported by the American Bureau of Metal Statistics, was 120,700 short tons, against 127,000 tons in July.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £18 3s. 9d.; Friday, £18 10s.; Monday, £18 6s. 3d.; Tuesday, £18 3s. 9d.; Wednesday, £18 1s. 3d.

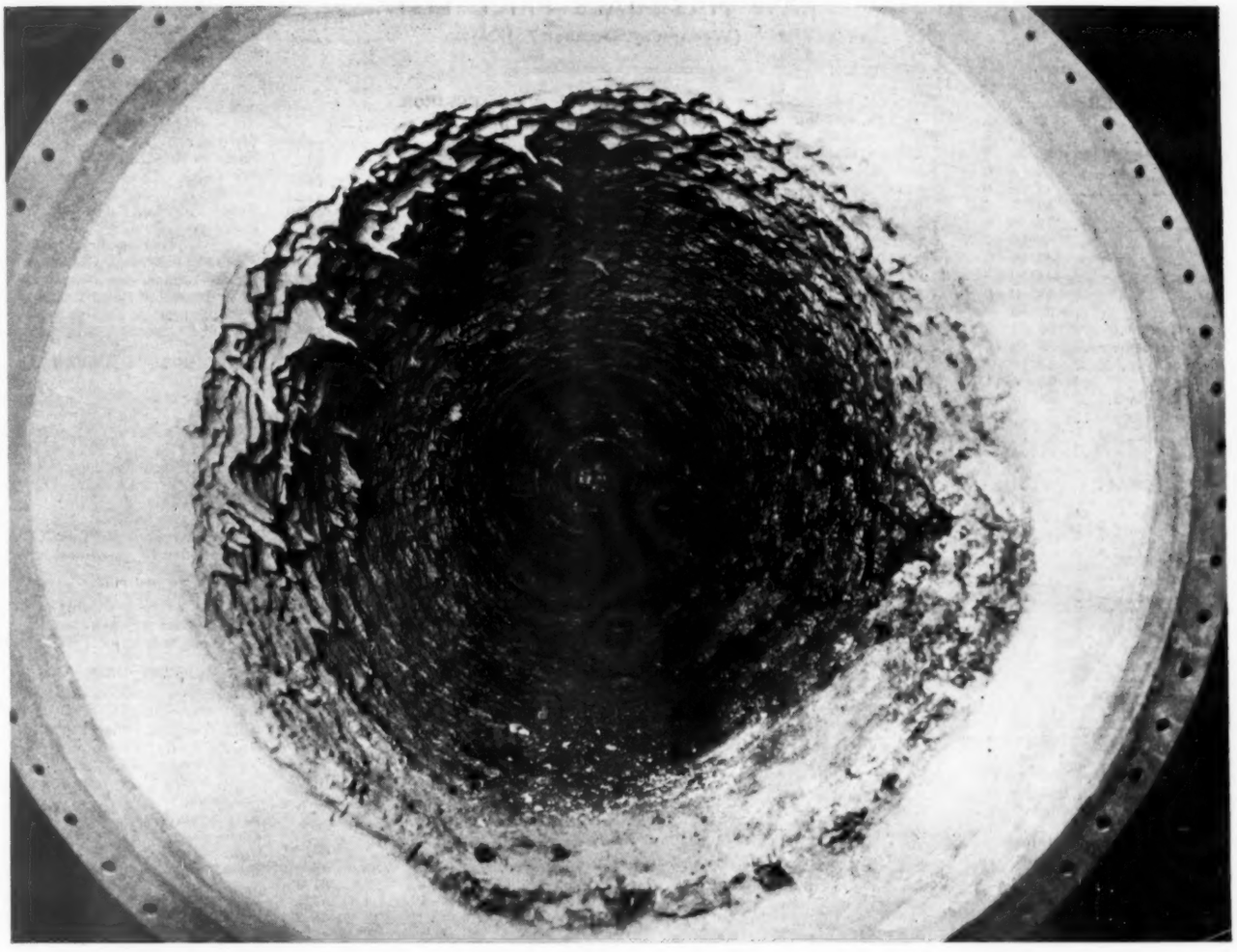
Company Meetings

Staveley Coal & Iron Company, Limited

Presiding at the annual meeting of the Staveley Coal & Iron Company, Limited, held in Sheffield last week, Sir William Bird (chairman), in moving the adoption of the report and balance-sheet, said that on the colliery side the trade during the past twelve months had been rather better than in recent years, with the exception of coal supplied to the textile trades, which did not seem to have recovered the whole of their old prosperity. The wet summer had kept the household trade busier than it would have been in normal years. The company's manufacture of pig-iron had increased during the year by 17 per cent. over the previous year.

F. H. Lloyd & Company, Limited

The annual meeting of F. H. Lloyd & Company, Limited, was held in Birmingham last week. Mr. F. J. Hemming, who presided, recalled that at their last meeting a hope was expressed that arrangements would be made to increase their capital during the year under review. This had happily been accomplished. Their bank overdraft and loan capital had disappeared, and they had now lying at their bankers adequate resources for expanding trade. Sales of castings and production of castings both constituted a record for the company. Improvement was even more marked than it was a year ago, and the directors saw no reason to anticipate any setback in the course of trade.



950 tons of metal melted—

The above photograph shows the condition of an 04 grade Albino lining in a 5-ton Brackelsberg furnace after 255 heats. You will observe the lining has worn back evenly and it is still approximately 8" in thickness. The 04 grade is specially produced for rotary furnaces, but there are other grades for lining cupolas, converters and ladles. This photograph is reproduced by courtesy of James Howden and Company (Land) Ltd.

ALBINO

ROTARY FURNACE LINING MATERIAL

Please write for further particulars to the sole manufacturers:

GENERAL REFRACTORIES LIMITED,

Genefax House, Sheffield, 10

Telephone: Sheffield 31113 (6 lines) Telegrams: "Genefax, Sheffield"

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

RAW MATERIALS—PRICE LIST

(Wednesday, October 7, 1936)

COPPER

	£ s. d.
Standard cash	39 15 0
Three months	39 16 3
Electrolytic	44 5 0
Tough	42 15 0
Best selected	43 5 0
Sheets	72 0 0
India	53 10 0
Wire bars	44 10 0
Ingot bars	44 10 0
H.C. wire rods	48 0 0
Off. av. cash, Sept.	38 19 0 5/8
Do., 3 mths., Sept.	39 3 5 1/2
Do., Sttlmnt., Sept.	38 18 10 1/4
Do., Electro, Sept.	43 10 1 1/4
Do., B.S., Sept.	43 1 11 1/2
Do., wire bars, Sept.	43 14 10 7/4
Solid drawn tubes	11d.
Brazed tubes	11d.
Wire	6 1/2d.

BRASS

Solid drawn tubes	10d.
Brazed tubes	12d.
Rods, drawn	9d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8 1/2d.
Wire	8d.
Rolled metal	7 1/2d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5 1/2d.
Do. 4 × 3 Sheets	5 1/2d.

TIN

	£ s. d.
Standard cash	202 0 0
Three months	198 15 0
English	202 0 0
Bars	204 5 0
Straits	204 10 0
Australian	202 0 0
Eastern	204 0 0
Banca (nom.)	204 0 0
Off. av. cash, Sept.	194 17 7 1/4
Do., 3 mths., Sept.	192 5 2 1/4
Do., Sttlmt., Sept.	194 16 1 7/4

SPELTER

	£ s. d.
Ordinary	13 17 6
Remelted	13 10 0
Hard	11 10 0
Electro 99.9	15 18 9
English	14 12 6
India	12 15 0
Zinc dust	19 15 0
Zinc ashes	4 10 0
Off. aver., Sept.	14 0 7 1/2
Aver. spot, Sept.	13 18 1 1/2

LEAD

	£ s. d.
Soft foreign ppt.	18 1 3
Empire	18 18 9
English	20 0 0
Off. average, Sept.	17 19 9 1/2
Average spot, Sept.	18 0 2 1/2

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	24 0 0 to 24 10 0
Do., V.M. ex-whse.	24 0 0 to 24 10 0
Rods	26 0 0

ANTIMONY

	£ s. d.
English	67 10 0 to 68 10 0
Chinese, ex-whse.	56 0 0
Crude, c.i.f.	27 0 0

QUICKSILVER

	£ s. d.
Quicksilver	13 5 0 to 13 5 6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	11 10 0 to 12 15 0
75%	16 12 6 to 17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	3/1 1/2 lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 0 0
4/6% car.	21 10 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.50% car.	37 5 0
70% carbon-free	9 1/2d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	6/3 to 6/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£11 5 0 to 11 15 0
76/80% packed	£12 5 0 to 12 15 0
76/80% export	£10 5 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/2 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 1/16 in.	1/- lb.
Flats, 1/2 in. × 1/4 in. to under 1 in. × 3/8 in.	3d. lb.
Do., under 1/4 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales—		
Heavy steel		3 4 0
Mixed iron and steel	2 18 0	to 3 0 0
Heavy cast iron	2 18 0	to 3 0 0
Good machinery	3 2 0	to 3 4 0
Cleveland—		
Heavy steel	2 17 6	to 3 0 0
Steel turnings		2 5 0
Heavy cast iron		3 5 0
Heavy machinery		3 7 6
Midlands—		
Light cast-iron scrap	2 12 6	to 2 15 0
Heavy wrought iron		3 5 0
Steel turnings		2 0 0
Scotland—		
Heavy steel		2 17 6
Ordinary cast iron	3 4 0	to 3 5 0
Engineers' turnings		2 2 6
Cast-iron borings		1 18 0
Wrot-iron piling		3 10 0
Heavy machinery		3 9 0

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	32 0 0
Brass	20 0 0
Lead (less usual draft)	16 10 0
Tea lead	12 0 0
Zinc	8 10 0
New aluminium cuttings	74 0 0
Braziery copper	29 0 0
Gunmetal	30 0 0
Hollow pewter	142 0 0
Shaped black pewter	107 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	77/6
,, No. 3	75/-
,, No. 4	74/-
Forge No. 4	74/-
Hematite No. 1	85/6*
Hematite M/Nos.	85/-*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
,, d/d Birm.	97/-*
Malleable iron d/d Birm.	125/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	77/-
,, No. 3 fdry.	80/-
Northants forge	74/6
,, fdry. No. 3	77/6
,, fdry. No. 1	80/6
Derbyshire forge	77/-
,, fdry. No. 3	80/-
,, fdry. No. 1	83/-
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/-
Cleveland No. 3, Glasgow	78/-
,, ,, Falkirk	75/-
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	74/6
,, fdry. No. 3	77/6
Lincs forge	74/6
,, fdry. No. 3	77/6
W.C. hematite	91/-*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	83/-
Staffs fdry. No. 3	83/-
Northants fdry. No. 3	81/6
Cleveland fdry. No. 3	83/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	91/-
Clyde, No. 3	91/-
Monkland, No. 3	91/-
Summerlee, No. 3	91/-
Eglinton, No. 3	9 /-
Gartsherrie, No. 3	91/-
Shotts, No. 3	91/-

* subject to a r bate of 5 . per ton und r certa n ondition .

FINISHED IRON AND STEEL

Usual district deliveries for iron ; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)		10 10 0
Nut and bolt iron	8 17 6	to 9 7 6
Hoops	11 7 6	and up.
Marked bars (Staffs) f.o.t.	13 0 0	
Gas strip	11 7 6	and up.
Bolts and nuts, 3/4 in. × 4 in.	16 0 0	and up.
Steel—		
Plates, ship, etc.	9 7 6	to 9 10 0
Boiler plts.	9 17 6	to 10 0 0
Chequer plts.		11 0 0
Angles		9 0 0
Tees		10 0 0
Joists		9 7 6
Rounds and squares, 3 in. to 5 1/2 in.		10 0 0
Rounds under 3 in. to 1/4 in. (Untested)		9 7 0
Flats—8 in. wide and over		9 5 0
,, under 8 in. and over 5 in.		9 10 0
Rails, heavy	8 5 0	to 8 10 0
Fishplates		12 10 0
Hoops (Staffs)		10 2 0
Black sheets, 24g. (4-t. lots)		12 0 0
Galv. cor. shts. (,,)		14 0 0
Galv. flat shts. (,,)		14 0 0
Galv. fencing wire, 8g. plain		15 0 0
Billets, soft		6 2 6
Billets, hard	7 2 6	to 7 7 6
Sheet bars		6 0 0
Tin bars		6 0 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10 1/2d.
Sheet to 10 w.g.	11 1/2d.
Wire	12 1/2d.
Rods	12d.
Tubes	14d.
Castings	12 1/2d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1 1/2 to 1/7 1/2
To 15 in. wide	1/1 1/2 to 1/7 1/2
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2 1/2 to 1/8 1/2
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3 1/2
Ingots rolled to spoon size	10d. to 1/6 1/2
Wire round—	
to 10g.	1/4 1/2 to 1/11 1/2

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3 1/2 upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.88
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37 1/2
Billets	30.00
Sheet bars	30.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.50
Sheets, galv., No. 24	3.20
Wire nails	1.90
Plain wire	2.40
Barbed wire, galv.	2.40
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/- to 32/6
,, furnace	24/6 to 25/-
Durham foundry	24/6
,, furnace	21/6
Scotland, foundry	30/-
,, furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20 × 14 per box	18/9
,,	28 × 20 ,,	37/6
,,	20 × 10 ,,	26/9 to 27/-
,,	18 3/4 × 14 ,,	19/6
C.W.	20 × 14 ,,	15/6 to 15/9
,,	28 × 20 ,,	33/9 to 34/-
,,	20 × 10 ,,	22/6 to 22/9
,,	18 3/4 × 14 ,,	15/3 to 15/9

SWEDISH CHARCOAL IRON & STEEL

Pig iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 1 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£2 0 0 to £23 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars an l rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£ s. d.	
Oct. 1 ..	39 13 9	inc.	11/3
,, 2 ..	39 10 0	dec.	3/9
,, 5 ..	39 15 0	inc.	5/–
,, 6 ..	39 15 0	No	change
,, 7 ..	39 15 0	,,	,,

Electrolytic Copper

		£ s. d.	
Oct. 1 ..	43 15 0	No	change
,, 2 ..	44 0 0	inc.	5 –
,, 5 ..	44 0 0	No	change
,, 6 ..	44 7 6	inc.	7/6
,, 7 ..	44 5 0	dec.	2/6

Standard Tin (cash)

		£ s. d.		
Oct. 1 ..	202 5 0	dec.	25/–
,, 2 ..	201 10 0	,,	15/–
,, 5 ..	202 15 0	inc.	25/–
,, 6 ..	202 10 0	dec.	5/–
,, 7 ..	202 0 0	,,	10/–

Tin (English ingots)

		£ s. d.		
Oct. 1 ..	202 10 0	dec.	20/–
,, 2 ..	201 10 0	,,	20/–
,, 5 ..	202 15 0	inc.	2 /–
,, 6 ..	202 15 0	No	change
,, 7 ..	202 0 0	dec.	15/–

Spelter (ordinary)

		£ s. d.		
Oct. 1 ..	13 17 6	inc.	3/9
,, 2 ..	14 1 3	,,	3/9
,, 5 ..	13 18 9	dec.	2/6
,, 6 ..	13 16 3	,,	2/6
,, 7 ..	13 17 6	inc.	1/3

Spelter (Electro, 99.9 per cent.)

		£ s. d.		
Oct. 1 ..	15 17 6	inc.	3/9
,, 2 ..	16 1 3	,,	3 9
,, 5 ..	15 18 9	dec.	2/6
,, 6 ..	15 17 6	,,	1/3
,, 7 ..	15 18 9	inc.	1/3

Lead (soft foreign, prompt)

		£ s. d.		
Oct. 1 ..	18 3 9	inc.	3/9
,, 2 ..	18 10 0	,,	6/3
,, 5 ..	18 6 3	dec.	3/9
,, 6 ..	18 3 9	,,	2/6
,, 7 ..	18 1 3	,,	2/6

Lead (English)

		£ s. d.		
Oct. 1 ..	20 5 0	inc.	5/–
,, 2 ..	20 10 0	,,	5/–
,, 5 ..	20 5 0	dec.	5/–
,, 6 ..	20 5 0	No	change
,, 7 ..	20 0 0	dec.	5/–

AVERAGE MONTHLY PRICES OF FURNACE COKE D/D MIDDLESBROUGH

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1904	0 13 9	0 13 9	0 13 3	0 14 3	0 14 6	0 14 3	0 14 3	0 14 3	0 14 3	0 14 0	0 14 0	0 14 6	0 14 1½
1905	0 14 9	0 15 3	0 15 3	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 9	0 17 0	0 15 5½
1906	0 17 6	0 17 6	0 17 0	0 17 0	0 17 0	0 16 6	0 17 0	0 17 0	0 18 3	0 18 6	0 19 0	1 0 0	0 17 8½
1907	1 4 6	1 5 0	1 5 0	1 0 6	1 2 0	1 1 0	1 1 0	1 1 0	1 2 0	1 1 6	1 0 0	0 17 0	1 1 8½
1908	0 16 0	0 16 0	0 15 6	0 16 0	0 16 3	0 16 0	0 15 6	0 15 6	0 15 6	0 15 3	0 16 0	0 16 0	0 15 9½
1909	0 16 0	0 15 3	0 15 0	0 14 9	0 15 6	0 15 9	0 15 6	0 15 6	0 16 6	0 17 0	0 17 6	0 17 0	0 15 11½
1910	0 18 4½	0 18 6½	0 18 0	0 18 0	0 17 10½	0 17 0	0 16 1½	0 15 9½	0 15 11	0 16 0	0 15 9½	0 15 8	0 16 11
1911	0 16 0	0 15 10½	0 15 6	0 15 3	0 14 9	0 14 6	0 14 6	0 14 6	0 14 6	0 14 11½	0 15 0½	0 16 3½	0 15 1½
1912	0 17 3	0 17 3	0 18 6	0 18 10	0 19 0	0 19 4½	0 19 10½	1 0 9½	1 2 9	1 4 1½	1 5 8½	1 8 6	1 1 0
1913	1 5 9	1 4 11	1 5 0	1 5 0	1 4 9½	1 0 4½	0 19 5½	0 18 3	0 18 0	0 18 2½	0 18 6	0 18 6	1 1 4½
1914	0 18 2	0 17 1	0 17 0	0 17 0	0 17 4	0 17 6	0 17 6	0 18 5	0 18 4	0 17 9	0 17 6	0 18 5	0 17 8
1915	0 17 10½	0 17 9	1 0 4½	1 7 7½	1 9 4½	1 10 7½	1 9 7	1 7 3	1 5 4	1 4 9	1 9 6	1 13 0	1 6 1
1916	1 10 9	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6½
1917	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 14 3	1 15 6	1 11 2½
1918	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6
1919	1 15 6	1 15 6	1 15 6	1 15 6	2 1 6	2 1 6	2 3 9	2 10 6	2 10 6	2 10 6	2 10 6	2 10 6	2 3 5
1920	2 12 3	2 14 0	2 19 0	2 19 0	3 3 8	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 2 6
1921	3 1 0½	2 19 0	2 16 0	2 7 0	2 6 6	2 6 6	2 0 6	2 0 0	1 13 11	1 12 9	1 10 4½	- -	2 3 6½
1922	1 7 0½	1 8 1½	1 9 7½	1 8 4½	1 7 11½	1 7 3	1 6 9½	1 6 10½	1 7 0½	1 10 2½	1 10 0	1 9 11½	1 8 3½
1923	1 11 3	1 14 6	2 0 1½	2 2 8½	2 4 4½	2 2 10½	2 1 0½	2 1 6	2 0 9½	1 18 9	1 18 8½	1 18 3	1 19 7½
1924	1 16 6½	1 14 9	1 11 11½	1 10 0½	1 8 1½	1 7 8½	1 7 3	1 6 3	1 6 0	1 5 0	1 5 0	1 5 0	1 9 5½
1925	1 4 10½	1 4 1½	1 13 3	1 2 4½	1 2 2½	1 1 5½	1 1 3½	1 4 9	0 18 10½	0 18 4½	0 19 6½	1 1 4½	1 2 8½
1926	1 2 1½	1 0 9	0 19 2½	0 18 6½	*	*	*	*	*	*	*	1 5 0	1 1 1½‖
1927	1 5 6	1 4 9½	1 6 1½	1 3 9	1 2 6	1 0 8½	0 19 4½	0 19 0	0 18 7½	0 18 0	0 17 10½	0 17 6	1 1 1½
1928	0 17 6	0 17 10½	0 18 0½	0 17 11½	0 17 8½	0 17 6½	0 17 7½	0 17 6½	0 17 6	0 17 7½	0 17 7½	0 17 6	0 17 8
1929	0 17 7½	0 18 0	0 19 0	0 19 6½	0 18 10½	0 19 10½	1 1 3½	1 1 ·½	1 3 0	1 3 6	1 3 8	1 3 1½	1 0 9½
1930	1 2 6½	1 1 3	1 0 3	0 19 1½	0 17 7	0 16 10½	0 16 6	0 16 6	0 16 9	0 17 0	0 17 0	0 17 0	0 18 2½
1931	0 17 0	0 16 7½	0 16 0	0 16 0	0 15 11	0 15 5	0 15 1	0 15 0	0 15 0	0 16 9	0 17 0	0 16 6	0 16 0½
1932	0 17 0	0 16 11½	0 16 5½	0 15 9	0 15 7½	0 15 6	0 15 6	0 14 9½	0 14 6½	0 14 6	0 14 6	0 15 6½	0 15 6½
1933	0 16 0½	0 15 11½	0 15 6½	0 15 6	0 15 6	0 15 6	0 15 6	0 15 8½	0 16 1½	0 17 0	0 17 6	0 18 9	0 16 1½
1934	0 19 1½	1 0 6	1 0 2	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	1 0 0	0 19 11½
1935	1 0 0	0 19 6½	0 19 0½	0 19 0	0 19 0	0 19 0	0 19 0	0 19 0	0 18 9½	0 18 9½	0 19 3½	1 1 2½	0 19 2½
1936	1 2 0	1 2 11½	1 3 2½	1 4 0	1 4 11½	1 4 3½	1 5 1	1 4 7½	1 4 6				

* Strike period. ‖ Five months.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.

ZETLAND ROAD, MIDDLESBROUGH.

Notice

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

FOUNDRY Foreman or working desires position. Practical, technical, bench, floor, stump, machine; good cupola practice; malleable, grey.—Box 920, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Position as Foreman or Assistant. Comprehensive practical experience, engineering; machine-moulding; modern methods. Technical knowledge. Keen and energetic.—Box 910, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

IRON Moulders required for a South Lancashire works. Stability of employment offered to good men used to medium and heavy castings. Healthy foundry in good district.—Box 924, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Foundry Foreman with wide experience of castings for general engineering and machine-tool trades. Castings up to 1 ton weight and output 200 tons weekly. Used to working with metallurgical control. Firm disciplinarian. Age not to exceed 45. State wages and experience.—Box 916, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Improver Chemist. Analysis of white and grey cast iron, etc., for a Midland foundry. State age, experience, and salary required, to Box 926, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

WORKS Chemist required for modern roll foundry. Previous experience, especially in connection with alloy rolls, considered desirable. Give full details age, training, salary required, etc. Confidential.—Box 928, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of The Foundry Trade Journal.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

BRASSFOUNDRY Foreman requires position or as Assistant in large foundry. Sound experience with first-class firms with high-pressure castings in gunmetal, phosphor bronze. Dry and green sand. Modern production methods. (285)

YOUNG Metallurgist requires situation. First-class experience, analysis of ferrous and non-ferrous metals, fuels, etc. Sand testing, mechanical testing, microscopic work. Works experience. Well trained technically. (286)

SITUATIONS VACANT AND WANTED.—*Contd.*

FOUNDRY Foreman requires position, preferably in Lancashire. Excellent experience with high-class work, including repetition work and moulding machines. Metal mixing. Accustomed to modern foundry plant, estimating and costing (287)

FOUNDRY Foreman requires position. Has had complete charge foundry and pattern-shop for several years. Wide experience, marine castings of all descriptions, including special irons; also non-ferrous experience. (288)

BUSINESS FOR SALE

FOR private disposal. Ironfoundry in South Yorkshire now working to capacity, 80 to 100 tons per month. A good open business, mainly engineering castings up to 3 tons in weight. Retirement sole cause of sale. Fullest investigation permitted. No genuine offer of prompt cash will be refused.—Address Box 922, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

MACHINERY

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. Brealey & Co., Ltd., Station Works, Ecclesfield, Sheffield.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. Davies & Son, West Gorton, Manchester.

Tilghman Sandblast Barrel Plants; barrel sizes—60 in. x 40 in.; 36 in. x 20 in.; 20 in. x 30 in.

Tilghman Sandblast Cabinet Plants; 4 ft. 6 in. and 3 ft. 6 in. square (one for high pressure 70 lbs. per sq. in.); also small Cabinet 30 in. dia.

All complete with Air Compressors, etc.

Gas and Air Mixer by Sharpe & Preston, 2-in. outlet.

Six Osborne Pneumatic Jolt Press Moulding Machines, size 75J.

Three Mumford Yoke Headpress Pneumatic Moulding Machines.

Two Herbert Whizzer Sand Disintegrators.

Two Brealey Type ditto.

Heavy Double-ended Grinding Machines by Rowlands, Luke & Spencer, etc.

Hand Moulding Machines by Adaptable Darling & Sellars, Pridmore, Samuelson, etc.

500 Electric Motors, Dynamos, Rotary Converters, etc.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.

CROSSWELLS ROAD (Adjoining Railway Crossing), LANGLEY, Nr. Birmingham.

'Phone: Broadwell 1359.

THOS. W. WARD LTD.

12" Jackman PLAIN JOLTER; table 5' square.

No. 6 Ajax Pneumatic JOLT-RAM ROLL-OVER MOULDER; 36" x 24" boxes.

Four MARINE BOILERS; 9' x 9' 2"; 200 lbs. w.p.

VERT. COCHRAN BOILER; 12' 3" x 5' 6"; 100 lbs. w.p.

Write for "Albion" Catalogue.

'Grams: "Forward." 'Phone: 23001 (10 lines).

ALBION WORKS, SHEFFIELD.

MISCELLANEOUS

FOR SALE.—One 9-ton Ladle; one 4-ton Ladle; one 30 cwt. Ladle. All worm geared.—C. J. Newton, Ltd., Crosfield Street, Warrington.

MISCELLANEOUS—*Continued*

BUY SKELMERSDALE STRAW ROPES, double-stranded, specially spun for core-making, prompt delivery, direct from the makers.
SKELMERSDALE STRAW ROPE WORKS, Moss Side, Skelmersdale, Lancs.

GENUINE Southport Wind Blown Sand, which makes best oil-sand cores. Prompt deliveries by road into works.
JOHN LIVESEY,
Sand Merchant,
SOUTHPORT.

IS IT BLACKINGS, PLUMBAGO AND FACINGS YOU NEED TO-DAY? Foundry blackings, all grades, our own production by the latest machinery; also pure Ceylon Plumbago (import direct). Core Gum, Parting Powder, Terra Flake, Coal Dust, Fireclay and Ganister. Our aim is quality at reasonable prices. Orders are repeated. Working samples sent free on application.—John & C. Durrans, Pennine Works, Hazlehead, near Sheffield. Telephone: Penistone 128. Telegrams: Facings, Penistone.

WHY WASTE MONEY by paying too high a price for your Blacking? Blacking of the highest quality, but quoted at very low prices, is obtainable from Jack Hibbert & Company, Limited, T.G. Dept., Octagon Works, Vicarage Road, Battersea, S.W.11. Send for free 1-cwt. sample for testing.

'Phone: 287 SLOUGH

MOULDING MACHINES

FOUR ADAPTABLE machines in good condition. Price **£14** each.

Two No. 6 Ajax 36" × 24" jolt pattern draw machines. Price **£55** each.

36" Metal Bandsaw, as new. Price **£25**

3" Nearly new Git Cutter, foot operated, Belt Drive.

15-cwt. Pooley Portable platform weighing machine. Price **£12.**

50 A.C. Motors & Compressors.

PLEASE SEND US YOUR ENQUIRIES.

Alex. HAMMOND, *Foundry Machinery Merchant,*
14, AUSTRALIA ROAD. SLOUGH
BUY FROM ME AND SAVE MONEY!

SELECT YOUR MACHINE FROM THE LARGEST STOCK OF HIGH-CLASS SECONDHAND MOULDING MACHINES IN THE WORLD

Practical Advice Free

C. W. COLEMAN,
156, STRAND, LONDON, W.C.2.